AN

# ANATOMICAL AND SURGICAL STUDY

OF

# FRACTURES OF THE LOWER END

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BY

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THE SAMUEL D. GROSS PRIZE ESSAY OF THE PHILADELPHIA ACADEMY OF SURGERY, 1910

LEA & FEBIGER

PHILADELPHIA AND NEW YORK

*Man hat entweder gut reponirt und bekommt gute Heilung,*
*oder man hat schlecht reponirt und bekommt schlechte Heilung*

TO

GWILYM G. DAVIS

M.D., UNIVERSITIES OF PENNSYLVANIA AND GÖTTINGEN

M.R.C.S., ENGLAND

ASSOCIATE PROFESSOR OF APPLIED ANATOMY IN THE UNIVERSITY OF PENNSYLVANIA

SURGEON TO THE EPISCOPAL HOSPITAL

SURGEON TO THE ORTHOPÆDIC HOSPITAL

THIS VOLUME

IS GRATEFULLY INSCRIBED

BY HIS

PUPIL, PROSECTOR, ASSISTANT, AND FRIEND

THE AUTHOR

1825 PINE STREET, PHILADELPHIA, April 26, 1910.

To DR. ASTLEY P. C. ASHHURST,
2000 West De Lancey Place, Philadelphia.

MY DEAR DR. ASHHURST:

It gives me great pleasure to announce to you that the Samuel D. Gross Prize of the Philadelphia Academy of Surgery for 1910, amounting to fifteen hundred dollars, has been awarded to you for your essay entitled "An Anatomical and Surgical Study of Fractures of the Lower End of the Humerus."

Allow me to congratulate you, and to assure you that the Trustees, Dr. Harte, Dr. Willard, and myself, believe your paper to be one of great value.

Yours very sincerely,
WILLIAM J. TAYLOR,
Chairman of the Trustees of the Samuel D. Gross Prize Fund.

WILLIAM J. TAYLOR, M.D.,
RICHARD H. HARTE, M.D.,
DE FOREST WILLARD, M.D.,
Trustees of the Gross Prize Fund and Library.

The conditions annexed by the testator are that the prize "shall be awarded every five years to the writer of the best original essay, not exceeding one hundred and fifty printed pages, octavo, in length, illustrative of some subject in surgical pathology or surgical practice, founded upon original investigations; the candidates for the prize to be American citizens."

It is expressly stipulated that the competitor who receives the prize shall publish his essay in book form, and that he shall deposit one copy of the work in the Samuel D. Gross Library of the Philadelphia Academy of Surgery, and that on its title-page it shall be stated that to the essay was awarded the Samuel D. Gross Prize of the Philadelphia Academy of Surgery.

Each essay must be distinguished by a motto, and accompanied by a sealed envelope bearing the same motto, containing the name and address of the writer.

The author is indebted to Dr. Charles M. Montgomery for the excellent skiagraphs of normal elbows; to Mr. S. J. Riegel, and to his successors as skiagraphers to the Episcopal Hospital, Drs. J. G. W. Havens, Henry Winsor, and W. H. Welker, as well as to Dr. William Van Korb, skiagrapher to the Orthopædic Hospital, for the skiagraphs of the various fractures. The photographs, made by the author, have been skilfully retouched by Mr. Charles F. Bauer.

The experimental and anatomical work was done in the laboratory of applied anatomy of the University of Pennsylvania. Most of the patients were treated in the author's services at the Episcopal and the Children's Hospitals.

As the essays are submitted anonymously, such references as might have served to disclose the author's identity have been added as the work was passing through the press.

A. P. C. A.

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# AN ANATOMICAL AND SURGICAL STUDY OF FRACTURES OF THE LOWER END OF THE HUMERUS

IT may seem a work of supererogation to study anew a subject which has already been so ably discussed by Allis, Roberts, Stimson, Lane, Cotton, Chutro, Mouchet, Destot, Vignard, Barlatier, and other surgeons of experience; and this, indeed, was my own opinion until recently. But evidences which constantly recur, both in literature and in practical work, demonstrating the actual ignorance of otherwise well-informed surgeons anent the anatomy and surgery of the elbow region, have convinced me that a further study of this subject is really of importance. To limit the scope of this essay, it has seemed best to confine it to a discussion of recent fractures involving the lower end of the humerus.

The older surgeons gained their experience of these injuries in the period before the use of the X-rays made possible the control and correction of a diagnosis; and many of the younger surgeons, taught by them, are growing up with the idea that after any such fracture a stiff elbow is to be anticipated; and that to prevent its development the most important thing is to encourage early motion—even to insist upon it to the extent of attempting to secure it by repeated and forcible manipulations.

Even those surgeons who have given particular attention to the subject of elbow fractures do not claim to achieve very good results. Thus, Destot, Vignard, and Barlatier, in their recent very admirable work upon the subject (Paris, 1909), think that "in about half the cases the ultimate results are bad;" and Mouchet (1909), who has himself had an extensive experience (169 cases), admits that though the proportion given by Destot, Vignard, and Barlatier is exaggerated if it applies to elbow fractures in general, yet it appears to him exact if reference is made only to supracondylar fractures (the most frequent variety). He writes that "the remote results are nearly always satisfactory in the fractures of the epitrochlea; satisfactory also, but less uniformly, in fractures of the external condyle; . . . these remote results are bad in half the cases of transverse supracondylar fractures." Chutro

(loc. cit, p. 143), with an experience of 35 supracondylar fractures, writes that the prognosis should be *reserved:* "There are not wanting those who give a favorable prognosis, being deceived by the happy termination of one or two cases which they have seen; but when these become more numerous they will learn that, in spite of most painstaking treatment, there will be unfortunate cases resulting in impaired function, and all this under the direct care of the physician, without his being able to prevent it." Even for supracondylar fractures without displacement, Chutro says (p. 146) that the patient and his family should be told that although the prognosis is more favorable than in other cases, yet that the range of motion, though free, will not equal the normal. For fractures involving the joint (external or internal condyle, epiphyseal separations, and transverse diacondylar fractures), both Mouchet and Chutro give a still more gloomy prognosis. Among 39 recent fractures of the lower end of the humerus treated by Destot, Vignard, and Barlatier, what might be called a perfect result was obtained in only 11, and in this class of "perfect" they include slight degrees of deformity not materially interfering with functional use of the arm; among 101 ancient fractures of the elbow region which they investigated, they found that a "perfect" result had been obtained in 38 (only 37.6 per cent.). Among 32 fractures of the lower end of the humerus studied very carefully by Cotton, there were only 5 in which a perfect result could be claimed, and in one of these five there was slight *cubitus valgus.* Cotton concluded, from his study, that in fractures of the external condyle some limitation of extension was to be expected, as also in separations of the internal epicondyle; while in supracondylar fractures he expected moderate loss of flexion and frequent deformity, usually of the gunstock variety.

Most of the text-books at present in use also give an unfavorable prognosis. Da Costa says: "The prognosis for complete restoration of function is bad, and in most of these fractures some deformity and considerable stiffness are inevitable. Ankylosis partial or complete is a not unusual sequence." Brewer writes: "The prognosis in every case should be guarded." Wharton says: "When fractures of the lower extremity of the humerus involve the elbow-joint, a certain impairment of joint motion is apt to occur either from ankylosis or from displacement of the fragments. . . . It is well to explain to the patient or his friends that impairment of joint motion may result in these fractures in spite of the greatest skill and care in the treatment." Stewart states: "The prognosis of fractures about the elbow should be guarded, and the danger of limitation of motion explained to the patient. In most instances, however, a useful arm is obtained, although this may not be for a number of months." Pilcher says: "Some limitation of the motions

of this joint is the rule after fracture in its vicinity, and complete ankylosis is not infrequent." Scudder says: "At the time of the first examination of the elbow the nature of the injury and its seriousness should be explained carefully to the patient or his friends. A guarded outlook should be expressed, particularly with reference to the function of the joint. Some limitation of motion may exist after all that is possible has been done." Miles and Thomson say: "Ankylosis, or, more frequently, locking of the joint, is a common sequel to many of these injuries." Rose and Carless give no very definite prognosis, but say: "If the joint has been involved, there is a great tendency to impairment of its usefulness, and passive movement should be started early."

Very few surgeons give a favorable prognosis. Roberts, it is true, as long ago as 1891, stated very explicitly that he approached an uncomplicated fracture of the elbow with the same certainty of getting a good result as he did in the ordinary fracture of the lower end of the radius; but he acknowledged the next year that his conclusions were based "on no definite number" of cases, and that this number had been small. Tiffany (1892) said: "In children, with any reasonably good treatment, we will have an arm which will ten years later be an excellent one." But ten years, it seems to me, is a long time to wait for a good result in a case of fracture. Eve (1907), though vaguely, gives a generally favorable prognosis. Eisendrath (1907) says: "In a properly managed case the prognosis, both in adults and children, is good as regards both deformity and restoration of function of the joint." Wilms (1904) admits that "the prognosis of supracondyloid fracture with the proper treatment is favorable;" but his further statement (loc. cit., p. 174), that "active and passive motion should be instituted in order to overcome at the earliest moment the resulting stiffness of the joints and fingers," shows that he usually anticipates stiffness; moreover, he states (p. 182) that "the involvement of the joint makes the prognosis of fracture of the external condyle unfavorable. . . . For this reason it is important to begin passive motion as soon as possible—that is, at the end of the second week, otherwise the limitation of motion is overcome with increasing difficulty."

Coenen (1908), basing his opinion on a series of 35 cases of supracondylar fracture treated by Ludloff and himself, concludes that it is in its results one of the most satisfactory of all fractures seen in children; but among 28 recent cases which he traced, he notes a perfect result in only 7, distinct limitation of motion in 12, *cubitus varus* in 7, *cubitus valgus* and Volkmann's ischæmic contracture in 1 case each.

It will be noted that in the above extracts from the writings of teachers of various nationalities the opinion is very generally expressed that deformity and interference with function are to be anticipated after a

fracture in the region of the elbow; that those few surgeons who give a favorable prognosis present no data to support their contention;[1] and that the authors who have most carefully studied and tabulated their results give an even more gloomy prognosis than do the others. Now, while I cannot hope to offer much that is new in regard to the applied anatomy of the subject, I do hope to show, by a detailed report of cases, accompanied in most instances by skiagraphs, and in many by photographs, that with common-sense surgical treatment, intelligently applied, the prognosis of any and all fractures involving the lower end of the humerus is much less gloomy than it has heretofore been considered, and that *in the vast majority of cases the ultimate results will be perfectly satisfactory.*

After a few preliminary remarks on the applied anatomy of the elbow region, and a discussion of the development of the lower epiphysis of the humerus, I shall consider briefly the causes, symptoms, and treatment of the typical fractures encountered, and shall add my personal statistics, showing the results obtained.

FIG. 1.—Lateral view of lower end of humerus.

## ANATOMY.

**The Adult Humerus.**—The humerus is a cylindrical bone, its lower extremity becoming gradually flattened antero-posteriorly, and broadened laterally, and terminating in the condyles, which may be roughly described as a cylinder affixed transversely to the *front* of the lower end of the humeral shaft. It is of particular importance to note that the lower extremity of the humerus is not attached in the same plane as the shaft of the bone; it is distinctly on the anterior surface of the shaft (Fig. 1). If it were placed directly on the end, the range of motion of the forearm posterior to the axis of the humerus would very nearly equal its range anteriorly (Fig. 2).

Looking at the humerus from the front, it is evident that the articular surface is not placed at right angles with the axis of the shaft, but obliquely (about 85 degrees), the lowermost part of the articular surface being on the inner side (Fig. 4). Thus, when the bones of the forearm are articulated with the humerus, they deviate *away from the body*, forming the "carrying angle" (p. 27) (Fig. 3).

[1] Siter (1905) reports in general very satisfactory results, but specifies only 6 cases.

The inferior extremity of the humerus is composed of the two condyles, *external* (or lateral) and *internal* (or medial); the depression in the centre of the shaft at the base of the condyles (formed by the olecranon fossa posteriorly, by the coronoid fossa in front) lies *within the elbow-joint* (Fig. 5). The articular part of the external condyle is called the *capitellum*, and articulates with the head of the radius; while the articular part of the internal condyle is called the *trochlea*, and articulates with the sigmoid cavity of the ulna. The prominent tubercle on the internal condyle above the trochlea is called the *epitrochlea* (internal epicondyle) and that on the external condyle is called the *epicondyle* (external epicondyle) (Fig. 6). The trochlea is concave from side to side, and convex antero-posteriorly, forming with the ulna a saddle-

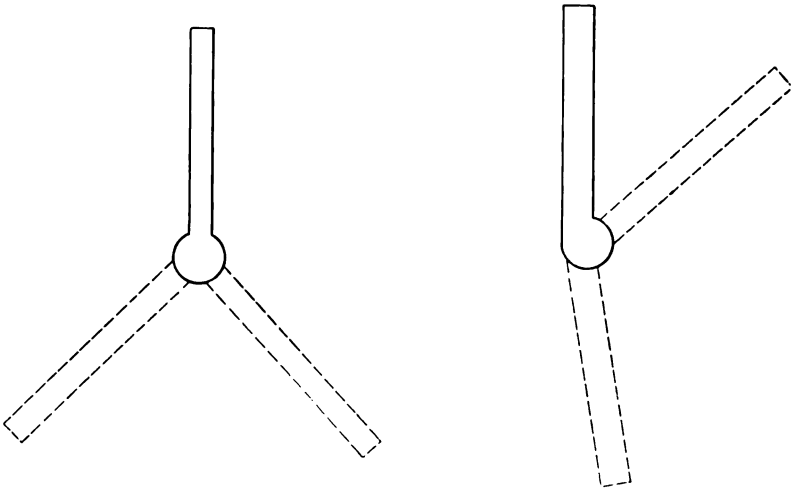


FIG. 2.—Diagram to show range of motion in elbow-joint.

shaped joint of considerable firmness, and permitting only a hinge-like antero-posterior motion. Of the two lips of the trochlea, the inner is much the more prominent. The capitellum is more or less spherical, and adapted to the concave shape of the radius; besides the antero-posterior motion occurring in this part of the elbow-joint, the head of the radius also rotates in its own axis, regardless of whether the elbow is flexed or extended, and entirely independently, therefore, of the relation of the ulna to the humerus. If the ulna were absent, the radius and capitellum would constitute practically a ball-and-socket joint, the radial head forming a shallow cup; this condition is simulated by fractures of the internal condyle (p. 82). If the radius were absent, the hinge-like motion of the ulno-humeral joint would still be preserved, unless either the outer or inner lip of the trochlea were fractured, when a lateral motion would be possible until the excursion of the ulna in either

FIG. 3.—The carrying angle.

FIG. 4.—Anterior view of lower end of humerus.

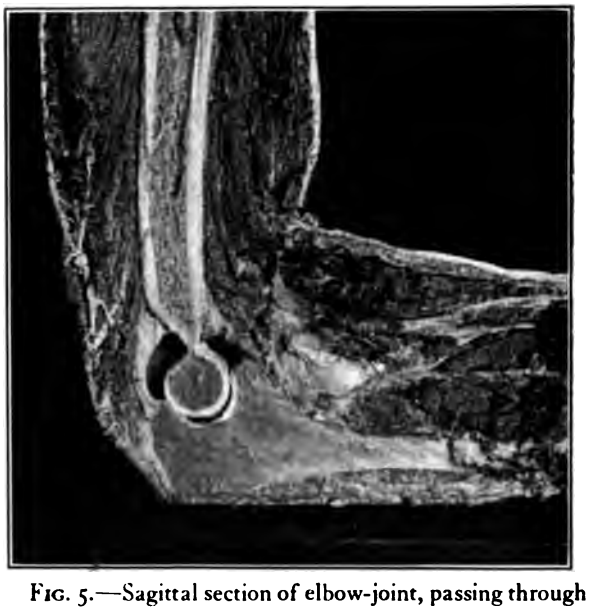


FIG. 5.—Sagittal section of elbow-joint, passing through the coronoid and olecranon fossæ. The capsule was distended before hardening in formalin.

abduction or adduction became checked by the lateral ligaments of the elbow. In some fractures of the external condyle (Cases 38, 40, 41), as will be seen presently, this condition is present, and the carrying angle may be lost by adduction of the ulna due to downward displacement of the external condyle, or may be markedly increased by its upward displacement.

**Limits of the Articular Surface** (Fig. 7).—Anteriorly the capsule is attached to the shaft of the humerus just *above* the coronoid and radial fossæ (Fig. 5). On the inner side it is attached to the base of the prominent inner lip of the trochlea, leaving the epitrochlea entirely extra-articular but bringing the whole inner lip of the trochlea within the joint cavity. On the outer side the capsule is attached to the rounded surface

FIG. 6.—Trochlea, capitellum, epitrochlea, and epicondyle.

FIG. 7.—Attachment of capsule of elbow-joint to humerus, from the front.

of the external condyle, bringing a small portion of the epicondyle within the joint cavity. Posteriorly the capsule is attached across the upper part of the olecranon fossa (Fig. 5), which is thus mostly intra-articular. To the ulna the capsule is attached *shortly below the tips* of the coronoid and olecranon processes, leaving these portions of the ulna *within the joint cavity*, to be received in the fossæ of corresponding name in the humerus (Fig. 5). Laterally the capsule is attached close to the margins of the greater sigmoid cavity of the ulna. The upper radio-ulnar joint is a diverticulum from the elbow-joint, formed between the circumference of the head of the radius and the lesser sigmoid cavity of the ulna. The capsule of the elbow-joint is attached to the radius below the orbicular ligament which surrounds the neck of this bone.

**Ligaments.**—The *capsular ligament* is strongest where re-inforced at the two sides by the *lateral ligaments*. If the capsule is cut away except where re-inforced in this way, the bones of the forearm and the humerus are still firmly united, and still only the normal antero-posterior motions are possible. The *internal lateral ligament* passes as two bands from the epitrochlea to the inner surface of the olecranon and coronoid processes of the ulna; the tendon of origin of the flexor muscles of the forearm is so firmly attached to it that it can with difficulty be dissected free. The *external lateral ligament* arises from the epicondyle and spreads out in two branches which embrace the head of the radius, blending with its *orbicular ligament*, and being inserted with it into the margins of the lesser sigmoid cavity of the ulna. The supinator (brevis) muscle is densely adherent to the external lateral ligament. A further band of fibres passes obliquely across the anterior part of the capsule from the epitrochlea to blend with the orbicular ligament of the radius (Fig. 11).

**Limitation of Motion in the Elbow-joint.**—I investigated the range of motion in 50 normal elbows of children (29 boys, 21 girls) less than fifteen years of age (average age, nine and one-tenth years). The limit of flexion varied from 14 degrees to 40 degrees, the average flexion being 31.1 degrees; the limit of extension varied from 170 degrees to 210 degrees (*i. e.*, 30 degrees hyperextension), the average extension being 186.98 degrees, or nearly 7 degrees of hyperextension beyond a straight line (180 degrees). In girls the average was 186.9 degrees; in boys it was 186.89 degrees.

*Flexion* is resisted first by contact of the soft parts and tension on the posterior branches of the lateral ligaments (Fig. 8); then by the impingement of the coronoid process upon the coronoid fossa, and to a slight degree by the contact of the radial head with the radial fossa (Fig. 11).

*Extension* is limited by tension on the anterior bands of the lateral ligaments (Fig. 9) and on the anterior capsule (Fig. 10); by tension on the overlying muscles, especially the brachialis anticus and biceps; also by the tip of the olecranon striking the olecranon fossa. The radial head does not pass posterior to the axis of the humerus (Fig. 12). The moderate normal hyperextension present in the elbow, as in other hinge joints (*e. g.*, the knee), exists for the purpose of increasing the stability of the extended position. If extension normally stopped at 180 degrees or less, the elbow when extended would be in constant danger of collapsing like a knife-blade into its sheath whenever the voluntary extending force of the triceps ceased to exert its influence. By allowing slight hyperextension, however, a position of relative stability is secured, even when voluntary action (muscles) is not being exercised; the relation of forearm to arm being maintained then by ligaments alone. If the

FIG. 8.—Right elbow flexed, to show tension on posterior branch of internal lateral ligament.

FIG. 9.—Right elbow extended, to show tension on anterior branch of internal lateral ligament.

FIG. 10.—Left elbow extended, showing tension on anterior ligament.

movement of extension is carried forcibly beyond the normal limit, into marked hyperextension, either the ligaments or the bones must break. In adults, whose bones are much stronger, dislocation usually occurs, resulting from rupture of the anterior ligament and the anterior bands of the lateral ligaments, especially of the internal lateral, on which the greater strain is exerted, owing to the existence of the carrying angle (see below); or the epitrochlea may be torn off. In children the bones are weaker than the ligaments, and the lower end of the humerus is frequently torn off in this manner.

FIG. 11.—Bones of left elbow in hyperflexion, viewed from outer side.

FIG. 12.—Bones of right elbow in extension, viewed from outer side.

The *position of greatest stability* is that of hyperflexion (flexion as acute as possible). In this position the action of the forearm as a lever is abolished. Whenever it is desired to use the forearm as a lever in rotating the humerus (as in H. H. Smith's and Kocher's methods of reducing dislocations of the shoulder), the forearm is flexed at right angles with the arm; and as the forearm is moved the motion is transmitted to the humerus by means of the lateral ligaments of the elbow. In any case of fracture of the lower end of the humerus, and especially in transverse fractures above the condyles, the slightest motion of adduction or abduction imparted to the forearm will likewise be transmitted to the humerus, *but will cause rotation only of the lower fragment of the humerus*, thus

easily producing motion at the seat of fracture and distorting the relation of the fragments. In the position of hyperflexion this lever action is abolished, as the axes of the forearm and arm more nearly coincide. It is true that in full extension the axes of the forearm and arm nearly coincide, and that leverage for rotation of the humerus is absent; but in full extension the forearm acts as a powerful lever in adducting or abducting the humerus to or from the body, and if any fracture of the humerus exists, the nearer it is to the elbow the more easily will the position of the lower fragment be influenced by adduction or abduction of the forearm (Fig. 13).

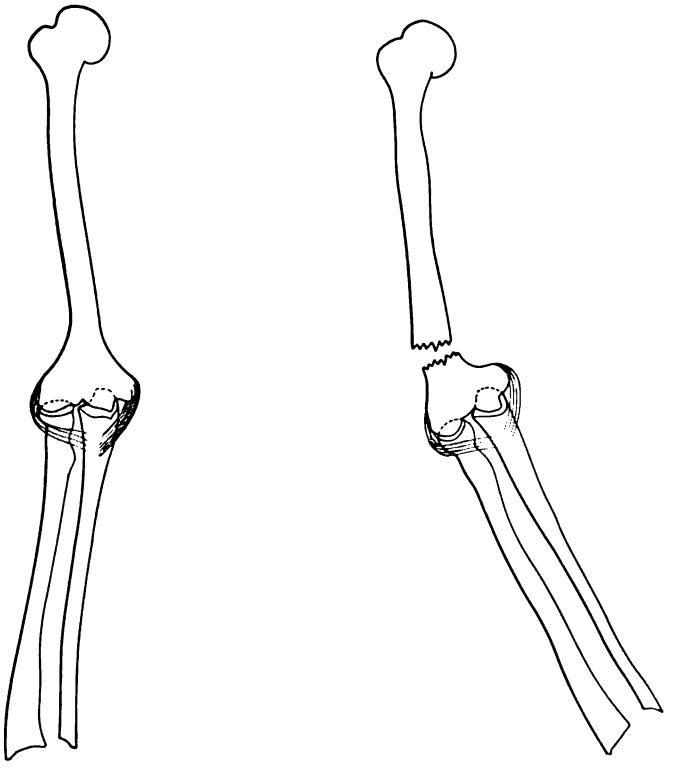


FIG. 13.—Action of forearm in extension, to adduct or abduct lower fragment in fracture of lower end of humerus.

In the position of hyperflexion the triceps acts as a natural splint to the lower end of the humerus, being tense and closely applied to the body of the bone, covering the posterior portions of the condyles and being continued around beneath the joint to spread out over the ulna in a broad fibrous aponeurosis (Fig. 58).

**Carrying Angle.**—In the above series of 50 cases, the carrying angle varied from 162 to 178 degrees, the average being 169.32 degrees. In

one case (a woman over forty years of age), not included in the series, I found the carrying angle 140 degrees in each elbow; as she had never suffered any injury or disease, it is probable that the *cubitus valgus* was due to rachitis in childhood. The carrying angle in girls averaged 168 degrees; in boys the average was 170.24 degrees. This shows that even before puberty girls have a greater deviation of the forearm from the axis of the humerus, anticipating the greater breadth of the pelvis in adult life.

The carrying angle is not formed solely, as is sometimes supposed, by a deviation from the transverse of the lower articular surface of the humerus (page 20); there is also a similar deviation in the upper articular surface of the forearm in relation to its longitudinal axis. Assuming

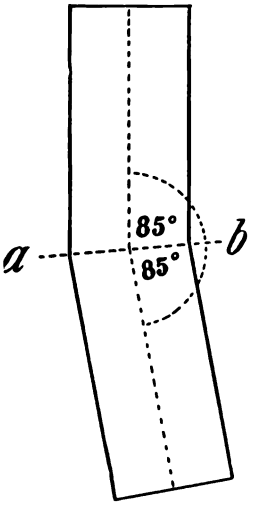



FIG. 14.—Diagram of carrying angle. (After Potter.)

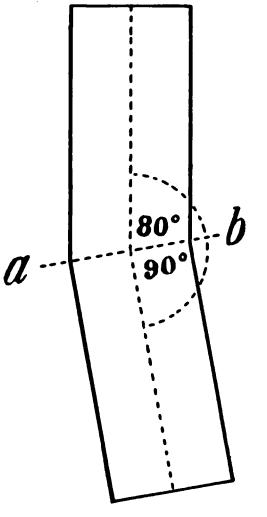



FIG. 15.—Erroneous conception of carrying angle.

that the carrying angle is 170 degrees, we have a deviation of 10 degrees from the straight line (180 degrees) to account for. Distributing this equally between the arm and the forearm at the elbow, we obtain the accompanying diagram (Fig. 14), modified from Potter, which shows the forearm making with the arm an angle of 170 degrees (85 degrees + 85 degrees), open externally, *a b* being the line of the elbow-joint. Were the entire 10 degrees requisite to form the carrying angle subtracted from the humerus, we should have the result shown in Fig. 15. The important difference between these figures is that on folding them along the line *a b* (the elbow-joint), the two portions of the diagram would be superposed in Fig. 14, whereas in Fig. 15 they would cross. Now, it is well known that in hyperflexion the forearm normally is superposed on the

arm, and that it does not cross its axis to come in contact with the chest. Figs. 16 and 17 are from photographs of a patient with a normal right elbow, but with an old fracture of the left elbow, which had healed with gunstock deformity. The change here has been the loss of the outward obliquity of the lower articular surface of the humerus; the lower articular surface of the humerus in this patient's left arm is approximately at a right angle with the long axis of the bone, so that when he flexes his forearm it does not become superposed on the humerus, as in the normal right arm, but crosses its axis and lies

FIG. 16.—Patient, showing normal carrying angle on right, and gunstock deformity on left.

FIG. 17.—Same patient, with both elbows flexed, showing deviation of left forearm from sagittal plane.

against the chest (Fig. 17). This question is of the utmost importance in the endeavor to preserve the carrying angle while treating fractures of the lower extremity of the humerus in the position of hyperflexion. If the forearm be brought up in such a manner that its axis coincides with that of the humerus, the carrying angle will be maintained; and with due regard to this point it is not necessary to have the forearm fully extended to assure one's self that gunstock deformity will not result.

## DEVELOPMENT OF THE LOWER EPIPHYSIS OF THE HUMERUS.

For clinical purposes there is no better way to approach this subject than by studying a series of skiagraphs of normal elbows. At birth the ends of all three bones forming the elbow-joint (humerus, radius, ulna) are entirely cartilaginous, and in skiagraphs seem to be separated by a considerable area, since cartilage is pervious to the Röntgen rays. The shaft or *diaphysis* of each of these bones seems in the skiagraph to have its end rounded off, being devoid of the prominences which are characteristic of the adult bone. One by one new shadows appear in the clear area occupied by the cartilaginous ends, as bone salts are deposited in the *epiphyses*. The clear area, composed of cartilage, which still separates these newly developed shadows (*epiphyseal centres*) from the diaphysis or shaft of the bone to which the epiphyseal centres belong, is called the *epiphyseal line*. It is well to bear clearly in mind the relation of *diaphysis*, *epiphyseal line*, and *epiphyseal centre*, as constant use will be made of these terms.

The epiphyseal centres around the elbow appear in the following order:

1. Capitellum of humerus in first half year of life.
2. Head of radius during the sixth year.
3. Epitrochlea about six years of age.
4. Trochlea during the eleventh year.
5. Olecranon later in the eleventh year.
6. Epicondyle in twelfth year. This centre frequently cannot be detected.

The three first-named are the most constant in the date of their appearance.

Fig. 18 represents the normal left elbow of a child considerably less than one year old. The humerus is viewed antero-posteriorly, as if seen from behind, and the forearm is pronated. It will be noted that the lower end of the humerus is symmetrical in outline, and that it would be impossible to tell, without looking at the upper end of the bone, at the forearm, or at the relation of the humerus to the body, which was the medial and which was the lateral side of the bone. The coronoid and olecranon fossæ are indicated by the lighter area in the centre of the lower end of the diaphysis. A considerable clear space separates the humerus from the bones of the forearm; this space is occupied by *cartilage*, which, of course, is pervious to the Röntgen rays, and produces no shadow on the plate. The only shadows cast are those of the *diaphyses* of the humerus, radius, and ulna. Note that *the coronoid and olecranon fossæ are in the diaphysis;* the lighter shadow cast by these

fossæ is a valuable landmark, and is of importance in the diagnosis of epiphyseal separations.

Fig. 19 is a nearly transverse view of the elbow of a child one year of age. The large clear cartilaginous space between the humerus and forearm still exists, and the profile view of the olecranon and coronoid fossæ gives the appearance of two wavy lines which converge and almost touch just above the lower limit of the diaphysis of the humerus, but

FIG. 18.—Skiagraph showing lower epiphysis of humerus in first half year (antero-posterior).

again diverge as this border is reached. Just below the diaphysis of the humerus, in the region occupied by the hitherto entirely cartilaginous epiphysis, can be detected the round shadow cast by the epiphyseal centre for the *capitellum of the humerus*. This is the first portion of the epiphysis in which bone salts are deposited with sufficient density to cast a shadow; it is the first centre to appear; and in my experience it has always been visible in skiagraphs of children twelve months of age or older. Dwight is almost the only authority who admits that this centre appears earlier than the end of the second year.

Fig. 20 shows the normal left elbow in antero-posterior view, seen from behind, at the age of three years. The centre for the capitellum of the humerus is considerably larger, but so far no other centre is visible. Fig. 21 shows a nearly lateral view of the elbow at the age of five years; the centre for the capitellum is still the only one visible. The converging lines which indicate the olecranon and coronoid fossæ are plainly seen.

Fig. 22 is an antero-posterior view of the normal right elbow, seen from in front, at the age of five years and eleven months. In addition to the centre for the capitellum, two other centres have now appeared;

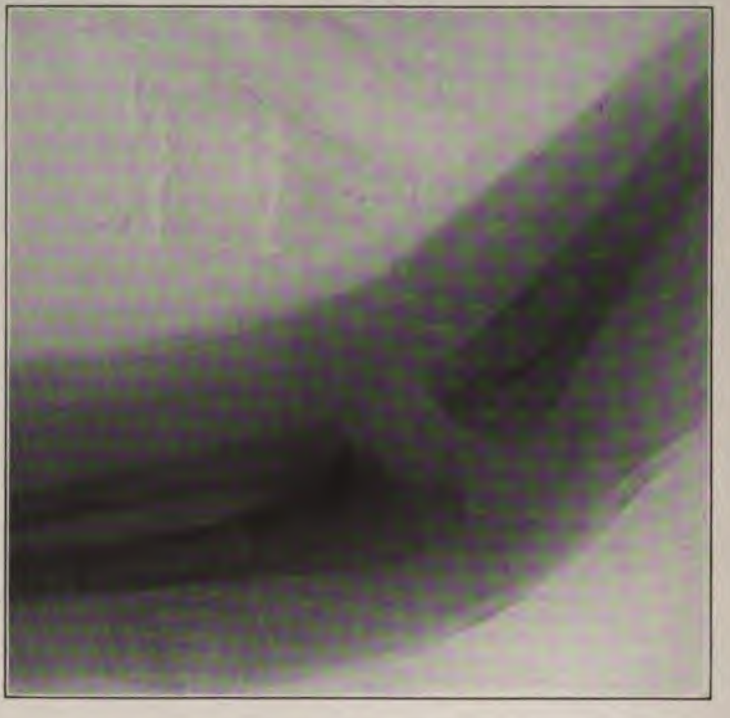


FIG. 19.—Skiagraph showing lower epiphysis at about one year of age (lateral).

the second to become visible (never before the age of five years) is that for the *head of the radius;* very faintly, also, may be detected the centre for the *epitrochlea* (internal epicondyle), which is invariably the third centre to appear. Comparing this figure with Fig. 20, it will be seen that the diaphyses of the humerus and ulna both have grown considerably, since, whereas in Fig. 20 there was quite an interval between them, in Fig. 22 (nearly three years later) their shadows overlap each other (see also page 80).

Fig. 23 shows the elbow at eleven years of age. It is an antero-posterior view of the right elbow, seen from in front. The centre for the capi-

FIG. 20.—Skiagraph showing lower epiphysis at three years of age (antero-posterior).

FIG. 21.—Skiagraph showing lower epiphysis at five years (lateral).

tellum has acquired almost adult proportions. The centre for the head of the radius has its typical appearance—that of a coin seen from the side. The centre for the epitrochlea is now quite distinct; and a new centre is just discernible—that for the *trochlea*—seen as a faint shadow close below the diaphysis of the humerus, between the shadows of the epitrochlea and ulna. Fig. 24 is a lateral view of the same elbow as that shown in Fig. 23; the centre for the capitellum and that for the head of the radius are clearly seen; the other centres cannot be distinguished in a lateral view.

In Fig. 25 is shown a side view of the elbow of a boy past ten years of age; the centre for the capitellum and that for the head of the radius

FIG. 22.—Skiagraph showing lower epiphysis at five years and eleven months (antero-posterior).

FIG. 23.—Skiagraph showing lower epiphysis at eleven years (antero-posterior).

are clearly seen, also that for the tip of the *olecranon*, which often does not appear so soon. It is important to note, what is demonstrated well in these lateral views, that the radius lies on a higher plane than does the ulna (Allis); this will be referred to again when discussing the treatment of fractures in this region.

Fig. 26 shows the elbow during the twelfth year. In addition to the centres for (1) the capitellum, (2) head of the radius, (3) epitrochlea, (4) trochlea (all of which are more developed and closer to their diaphyses than in Fig. 23), there is also clearly shown in this figure the

centre for the *epicondyle* (external epicondyle), just at the level of the epiphyseal line, on the outer side of the joint.

FIG. 24.—Skiagraph of lower epiphysis at eleven years (lateral).

FIG. 25.—Skiagraph of lower epiphysis during eleventh year (lateral).

Fig. 27 shows the elbow at twelve years and three months. The view is not quite antero-posterior, but slightly oblique. The obliquity accounts for the prominence of the capitellum. In addition to the epiphyseal centres seen in the last figure (capitellum, head of radius, epitrochlea, and trochlea), the centre for the olecranon process of the ulna is visible (compare Fig. 25), above the body of the ulna, and seen through the shadow of the humeral diaphysis, just to the lateral (radial) side of the centre for the epitrochlea. Usually the centre for the olecranon appears in the eleventh year.

Fig. 28 (aged thirteen years, ten months and a half) shows close approach to the adult type, though the epiphyseal lines are still indicated. The epicondyle appears to be fusing with the capitellum, and this latter

Fig. 26.—Skiagraph of lower epiphysis during twelfth year (antero-posterior).

Fig. 27.—Skiagraph of lower epiphysis at twelve years and three months (oblique).

has already fused with the trochlea. These centres usually unite with the diaphysis about the age of fifteen years, while that for the epitrochlea remains distinct from them, and does not unite with the shaft until the eighteenth year. This fact, together with other influences to be discussed presently, accounts for the relative frequency of detachment of the epitrochlea as an isolated injury.

Fig. 29 (aged fifteen years and two months) is from the oldest subject I have been able to procure in whom any indication of an epiphyseal line remains. The line between the epitrochlea and the diaphysis is still distinct, while the rest of the epiphyseal line is almost obliterated.

## CLASSIFICATION.

On account of the irregularity of the articular surface of the lower end of the humerus, the variety of fractures encountered is large; and the complexity of the development of the epiphysis adds to the orthodox

FIG. 28.—Skiagraph of lower epiphysis at thirteen years, ten months and a half (antero-posterior).

FIG. 29.—Skiagraph of lower epiphysis of humerus at fifteen years and two months (antero-posterior).

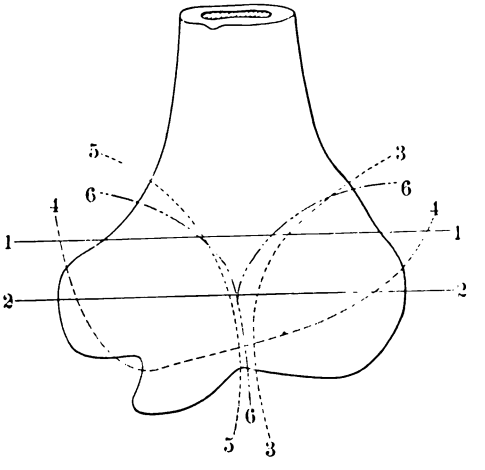



FIG. 30.—Diagram to show classification of fractures (modified from Kocher).

*fractures* a number of *epiphyseal* separations whose symptoms and clinical course so closely resemble those of the corresponding fractures that it is not worth while to consider them apart.

The accompanying diagram (Fig. 30), modified from Kocher, shows the lines of the principal fractures. The nomenclature employed by writers of different nationalities is not uniform, but I have adopted the following, which, though not that customary in English works on surgery, has the merit of simplicity:

1. Supracondylar.
2. Diacondylar.
3. External condyle.

} These three are the most frequent varieties.

4. Separation of entire lower epiphysis.
5. Internal condyle.
6. Intercondylar, T or Y.
7. Trochlea.
8. Epitrochlea.
9. Epicondyle.
10. Capitellum.

TABLE SHOWING THE RELATIVE FREQUENCY OF VARIOUS FRACTURES OF THE LOWER END OF THE HUMERUS.

| Type. | Author. | Chutro. | Cotton. | Destot, Vignard, and Barlatier. | Mouchet. | Kocher. | Judet. | Müller. |
|---|---|---|---|---|---|---|---|---|
| 1. Supracondylar (including diacondylar) | 29 | 40 | 13 | 39 | 78 | 13 | 39 | 36 |
| 2. External condyle | 12 | 28 | 16 | 15 | 51 | 14 | 11 | 23 |
| 3. Epitrochlea | 3 | 5 | 3 | 13 | 32 | 6 | 10 | 7 |
| 4. Epiphyseal separation | 7 | 29 | .. | .. | 3 | | | |
| 5. Internal condyle | 4[1] | 2 | .. | 2 | 1 | 6[1] | | |
| 6. Intercondylar | 1 | 2 | .. | .. | 2 | 2 | | |
| 7. Trochlea | | | | | | | | |
| 8. Epicondyle | .. | .. | .. | .. | 3 | | | |
| 9. Capitellum | .. | .. | .. | .. | .. | 4 | | |

**Supracondylar fractures** are those in which the line of fracture passes nearly transversely across the humerus from epitrochlea to epicondyle. They should be distinguished from fractures of the *lower third of the humerus* (Fig. 31), which in some books are still figured as supracondylar fractures. Fig. 32 shows a typical supracondylar fracture; in the vast majority of cases the line of fracture is higher on the posterior than on the anterior surface of the humerus, and the lower fragment is displaced posteriorly. Such a displacement has been described by Kocher as a *fracture by extension*, as the injury usually is received with the elbow extended, and the fragment is displaced toward the extensor surface. In very rare cases the line of fracture runs from the anterior surface of

[1] Diagnosis uncertain in 2 cases.

the humerus downward and backward, and the lower fragment is displaced forward, into the bend of the elbow ("*fracture by flexion*" —Kocher), as shown in Fig. 33. Mouchet saw this displacement only

FIG. 31.—Skiagraph of fracture of lower third of humerus (lateral).

FIG. 32.—Skiagraph of supracondylar fracture (lateral).

FIG. 33.—Skiagraph of supracondylar fracture by "flexion" (lateral).

FIG. 34.—Skiagraph of diacondylar fracture (antero-posterior).

FIG. 35.—Skiagraph of diacondylar fracture (antero-posterior).

once among 78 supracondylar fractures, in his sixty-second case; I have never encountered it in a recent case.

**Diacondylar fracture** is a term employed by Kocher to describe a more or less transverse fracture passing through the condyles, that is, below the line of supracondylar fracture but yet above the epiphyseal line. This type of fracture is called by Stimson a low supracondylar fracture, but as it is distinctly *through* the condyles, not *above* them, it has seemed better to adopt Kocher's term. Many writers do not distinguish it from the supracondylar type, and in some instances it is almost like

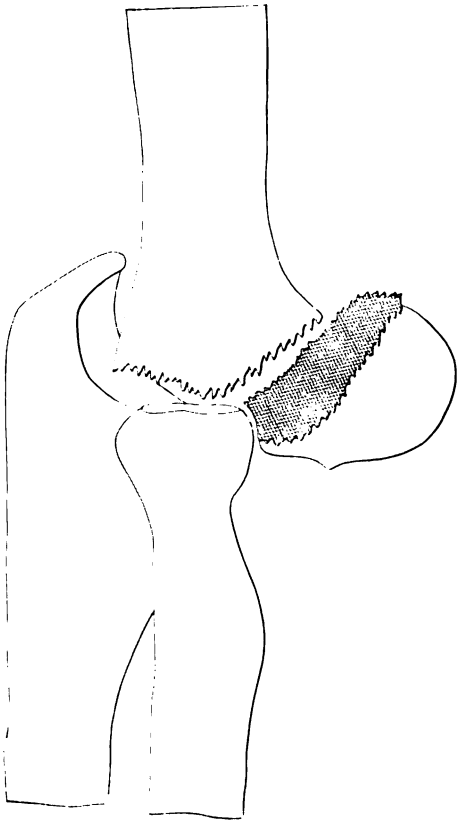


FIG. 36.—Diagram of diacondylar fracture of the type "Posadas." (After Chutro.)

splitting hairs to do so. Some surgeons (Scudder, Eisendrath, and others) have in a most unaccountable manner confused it with epiphyseal separations. The fracture usually crosses the olecranon fossa (Figs. 34 and 35). Sometimes there is no displacement of the lower fragment, but it usually is displaced posteriorly, like a supracondylar fracture; anterior displacement is rare. It is unusual for the lower fragment to be displaced *directly* either forward or backward; it is exceed-

ingly prone to be forced also either inward or outward. Chutro has called attention to an unusual type of diacondylar fracture, first recognized in 1901 as a distinct type by the late Prof. Posadas, of Buenos Aires, and now generally known by his name. It consists in a transverse diacondylar fracture by flexion (the lower fragment being displaced forward into the bend of the elbow) complicated by a posterior luxation of the radius and ulna, which, if not replaced, may come in time to form a false joint with the lower end of the upper fragment (Fig. 36). According to Chutro, descriptions of lesions probably similar had been recorded previously by Cruveilhier (1829), Dauvergne (1873), and by Pitha and Billroth (1873); and in searching through several thousand skiagraphs, made during the last ten years or more, I have encountered three or four examples of this fracture which do not appear to have been recognized as a type. All the cases hitherto recorded, so far as I am aware, have recovered with elbows ankylosed in nearly complete extension, and apparently have not attracted particular attention until operative relief of this ankylosis was contemplated. This was the case in all five of Chutro's patients; so that I esteem myself fortunate in having seen and recognized this injury as an acute condition in Case 28, and in having secured without open operation the very satisfactory result there recorded. The accompanying skiagraphs (Figs. 37 and 38) show the typical appearance of an elbow ankylosed as a result of this fracture.

**Fractures of the external condyle** usually detach the entire outer part of the lower extremity of the humerus, the line of fracture passing from above the epicondyle to enter the joint at or near the centre of the trochlear surface of the humerus. Figs. 39 and 40 show two typical examples.

**Fractures of the epitrochlea,** or epiphyseal separations of the centre for the epitrochlea, are by some surgeons called fractures of the internal condyle; but it has always seemed to me clearer to define the internal condyle (as at page 21) as including both epitrochlea and trochlea, thus making it correspond to the analogous part of the femur. Detachment of the epitrochlea is a frequent injury, and probably often passes unobserved. A typical skiagraph is reproduced as Fig. 41. This lesion often accompanies posterior dislocation of the elbow-joint as seen in Fig. 42.

**Separation of the Lower Epiphysis.**—This injury may occur at any age up till the time (about fifteen to seventeen years) when the epiphyseal line disappears, but is rare after twelve or thirteen years of age. It is exceedingly common for a small shell of the diaphysis to be detached with the epiphysis, as seen in Fig. 43. If a shell of bone all across the diaphysis is detached, the injury must be classed as a diacondylar fracture. If *no portion of the diaphysis is detached the line of separation*

FIG. 37.—Skiagraph of diacondylar fracture of the type "Posadas" (lateral).

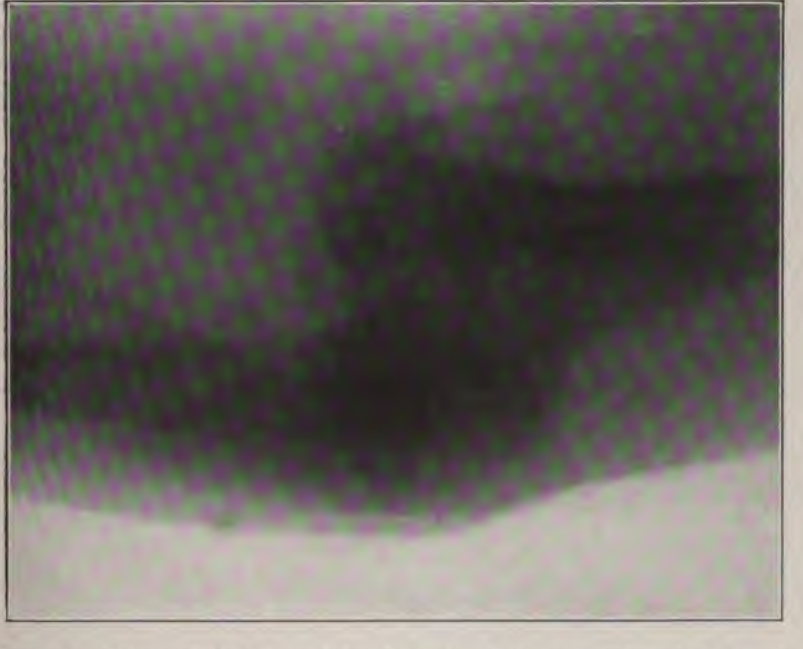


FIG. 38.—Skiagraph of diacondylar fracture of the type "Posadas" (nearly antero-posterior).

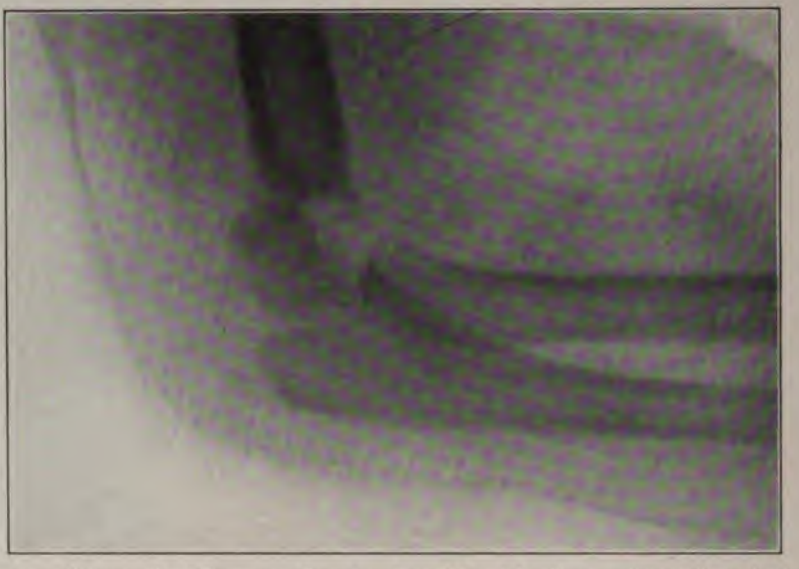


FIG. 39.—Skiagraph of fracture of external condyle; left elbow, viewed from behind and inner side.

FIG. 40.—Skiagraph of fracture of external condyle (oblique).

*passes directly along the epiphyseal line (cartilage), and hence will not be visible in a skiagraph.* Under such circumstances the diagnosis rests on the symptoms alone, or on the displacement of the visible epiphyseal centres as seen in a skiagraph made before reduction has been accom-

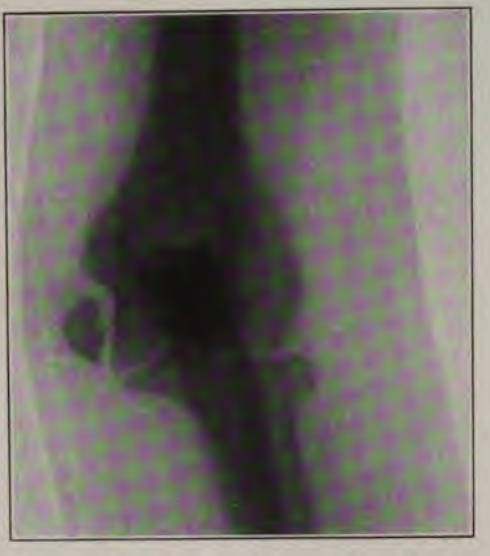


FIG. 41.—Skiagraph of fracture of epitrochlea (antero-posterior).

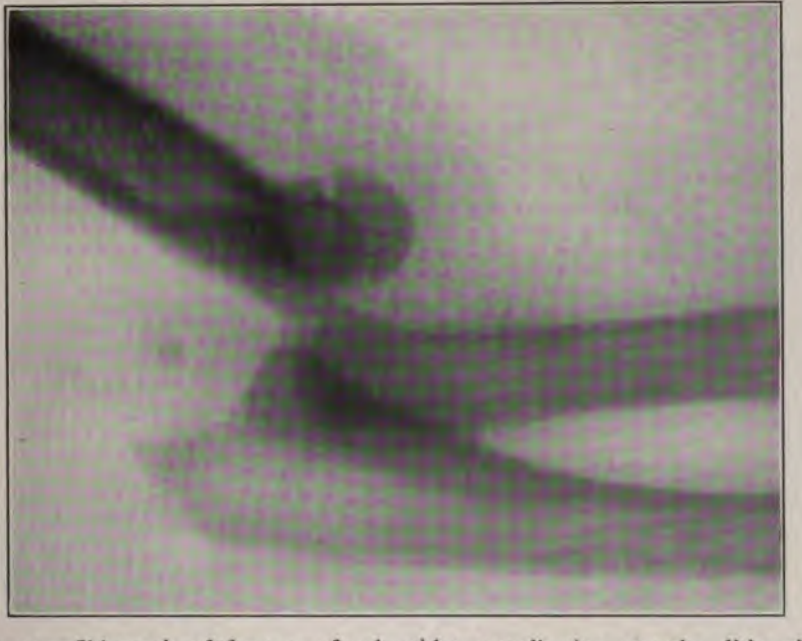


FIG. 42.—Skiagraph of fracture of epitrochlea complicating posterior dislocation of elbow (lateral).

plished. I have no doubt that many injuries to the elbow which in reality are epiphyseal separations are overlooked on this very account, because no line of fracture is seen in the skiagraph; and conversely it is true that many cases of diacondylar fracture are wrongly classed as epiphyseal separations, because the surgeon does not know where the epiphyseal line really is.

FIG. 43.—Skiagraph of separation of lower epiphysis, with shell of bone torn off diaphysis (antero-posterior).

**Fractures of the Internal Condyle.**—By this term I mean a fracture such as that shown in Fig. 44, where the entire inner part of the articular extremity of the humerus is detached. The line of fracture is usually more or less longitudinal, corresponding to the typical fracture of the internal condyle of the femur, and enters the joint at or near the centre of the trochlear surface. Fig. 45 shows a fracture of the internal condyle without displacement.

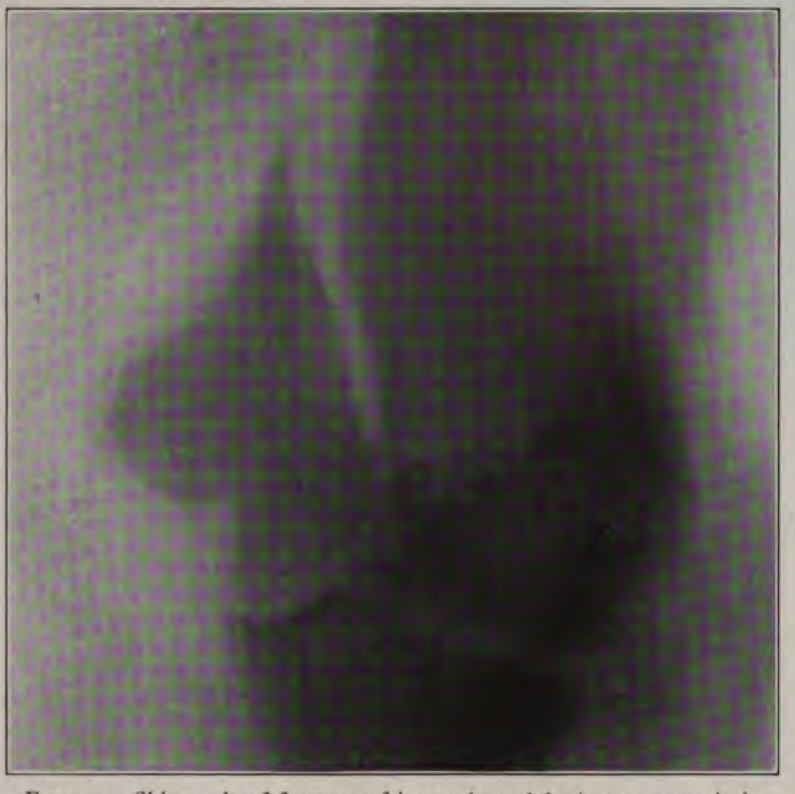


FIG. 44.—Skiagraph of fracture of internal condyle (antero-posterior).

FIG. 45.—Skiagraph of fracture of internal condyle without displacement.

FIG. 46.—Skiagraph of atypical fracture of lower end of humerus (antero-posterior).

**Intercondylar Fractures.**—These are fractures which separate the condyles from each other and from the shaft of the humerus as well. The line of fracture thus somewhat resembles a Y or T. They are generally acknowledged to be rare injuries, and I am inclined to believe they are much more unusual than generally supposed. In studying a series of several thousand skiagraphs I have noticed that the fracture represented in Figs. 46 and 47 is a much less rare injury, and that it commonly is described as a T-fracture. This, it will be noticed, it is not; the line of fracture (Fig. 46, antero-posterior) passes transversely through or just above the condyles, and the lower fragment embraces in one piece

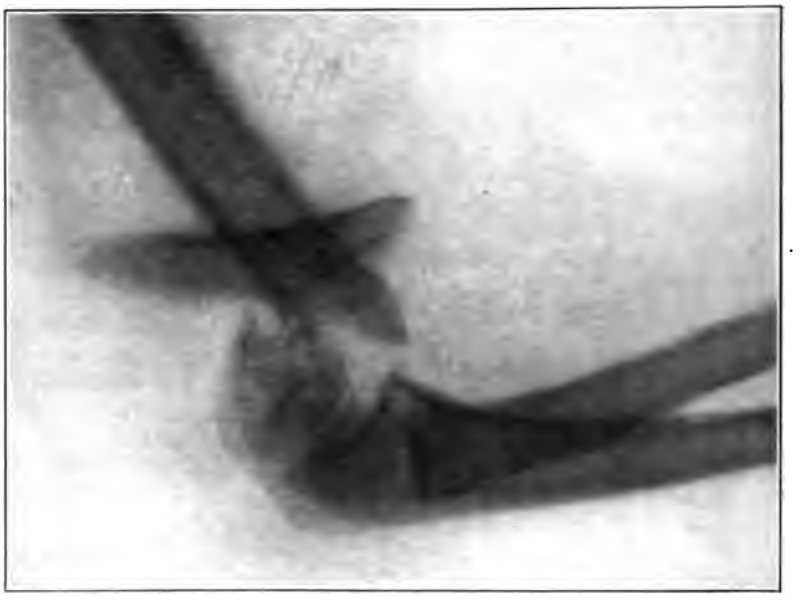


FIG. 47.—Skiagraph of atypical fracture of lower end of humerus (lateral).

the entire epiphysis and the lower end of the diaphysis; the second fragment is formed by a splinter of the shaft above the internal condyle, but as is plainly seen in the lateral view (Fig. 47) this detached fragment does not extend to the articular surface as it would do if composed of the internal condyle itself. I have been entirely unable to find any skiagraph showing in antero-posterior view a true intercondylar fracture.[1] The nearest approach to this is in Case 56 (Fig. 150), which I classed as a fracture of the internal condyle alone until the skiagraph showed there was also a fracture, probably impacted, of the external condyle; in this patient there is no doubt whatever that the internal condyle was

[1] Since writing the above I have seen one case where the skiagraph confirmed the diagnosis.

fractured into the joint, and that the external condyle also was fractured, although impacted into and not detached from the shaft.

**Fracture of the Trochlea.**—Isolated detachment of the trochlear surface or of a part of it I have not observed. Stimson gives an illustration of a case under his care.

**Fracture of the epicondyle** (external epicondyle) is exceedingly unusual, though Mouchet claims to have recognized it three times. Gurlt describes two extra-articular fractures of the epicondyle. If the fragment detached is so large as to involve the joint it will be better to class the fracture with those of the external condyle.

**Fracture of the capitellum** is the least unusual of these rarer fractures. Stimson refers to a number of cases. Fig. 48 shows a partial fracture of the capitellum which I produced experimentally (see page 52). The fragment detached is completely intra-articular.

FIG. 48.—Photograph of experimental fracture of capitellum.

Enumeration of these *typical* fractures does not exclude the existence of a goodly number of *atypical* fractures. These usually are produced by such great violence as to be compound or otherwise complicated, and therefore do not come within the limits set for this monograph.

## GENERAL MECHANISM BY WHICH FRACTURES OF THE LOWER END OF THE HUMERUS ARE PRODUCED.

1. *In falls upon the outstretched hand* the force is transmitted chiefly to the radius, as the ulna does not articulate with the carpal bones. From the radius the force is transmitted directly to the *external condyle* of the humerus, the head of the radius impinging upon the capitellum (Fig. 49). The force received upon the hand is transmitted to the *internal condyle* only by first reaching the ulna through the medium of

the interosseous ligament (Fig. 49), the fibres of which, passing obliquely downward from the radius to the ulna, are well adapted to distributing such a strain. If they ran from the ulna obliquely downward to the radius such a distribution of the force would be impossible. Falls upon the hand are very rarely followed by fractures of the internal condyle; they usually produce a fracture of the external condyle alone, or, more frequently, a transverse fracture above the condyles. The elbow usually is more or less extended in falls upon the outstretched hand; in most cases it is fully extended; and I think the greater frequency of supra-condylar fractures as compared with those of the external condyle alone

FIG. 49.—Mechanism of fracture of external condyle from fall on hand.

is no doubt partly due to the action of the anterior ligament and anterior bands of the lateral ligaments, which tear off the lower extremity of the humerus when hyperextension follows a fall on the outstretched hand. The longitudinal fibres of the anterior ligament, passing from above the coronoid fossa of the humerus to the base of the coronoid process of the ulna, are strong enough to stand considerable strain without breaking; and they are re-inforced by oblique fibres passing from the epitrochlea to the orbicular ligament of the radius (Fig. 10). In hyperextension of the elbow these two band-like portions of the anterior ligament are put on the stretch, and, together with the anterior bands

of the two lateral ligaments, hold the forearm very firmly in contact with the humerus. If it is desired to rupture these bands, as in producing an experimental dislocation of the elbow by means of hyperextension, the hyperextension must be gradually and carefully done. Sudden hyperextension is much more apt to cause fracture.

Of course, the direct thrust from the fall (transmitted through the radius and indirectly through the ulna) has probably even more to do with breaking off the lower end of the humerus; but if this were the only cause, anterior displacement of the lower fragment would not be so rare. For as the articular surface of the humerus is on a plane anterior to the long axis of the bone, a simple upward thrust transmitted from the forearm in full extension would be more apt to displace the lower fragment forward than posteriorly. So that it seems impossible to deny, as has been done by Destot, Vignard, and Barlatier, the important influence of the ligaments in tearing the fragment loose as the elbow is hyperextended by the impact of the hand with the ground; and if this be admitted, the posterior displacement of the fragment follows as a matter of course. If these fractures were produced by falls upon the hand with the elbow flexed at a right angle (which they are not), then the theory of simple thrust would have to be admitted, and the posterior displacement without leverage by hyperextension could be understood. But the elbow cannot be so firmly fixed by the muscles as to remain flexed at a right angle (more or less) when the patient falls on the outstretched hand; the elbow is either violently hyperextended (as in the mechanism discussed above), or it suddenly collapses, a much less usual sequel. In only one instance (Case 50) have I found a distinct injury following a fall on the hand which produced *acute flexion* of the elbow; in this case the result was an epiphyseal separation. In Case 11 the production of a supracondylar fracture by pure hyperextension is well illustrated, as this boy did not fall on his outstretched hand, but on the flexor surface of his fully extended forearm, the elbow being thus violently hyperextended, and very little if any upward thrust being transmitted to the humerus from the forearm.

The greater frequency of fractures of the epitrochlea, as compared with those of the epicondyle, may also be accounted for by the theory of ligamentous distraction; since it is quite evident, owing to the existence of the carrying angle, that in falls upon the hand with the elbow extended the internal lateral ligament receives a greater part of the strain than the external; and it is well known that in dislocations of the elbow the internal lateral ligament is more widely ruptured than the external, in spite of its greater strength. The existence of the carrying angle at the elbow may also be invoked as a partial explanation of the frequency of fractures of the external condyle following falls on the hand,

as the external condyle is found in the line of compression. Force applied at the extremities of two lines joined at an angle tends to diminish that angle by approximating the ends of the lines. Thus in Fig. 50, if force acts in the direction of the arrows, from A and D, the line AO will much more readily be forced into the position BO than into that of CO. The mere act of hyperextension of the elbow, produced by falls on the hand when the elbow is already fully extended, usually causes more injury to the external than to the internal condyle, possibly owing to the mechanism suggested in Fig. 50. In producing an experimental dislocation of the elbow by hyperextension, I succeeded in obtaining not only the fracture of the capitellum shown in Fig. 48, but also a splitting fracture of the head of the radius; both these injuries evidently

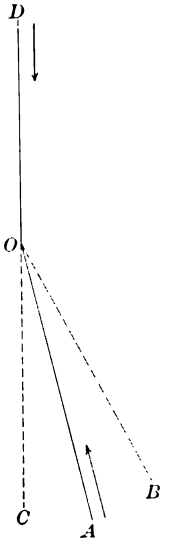



FIG. 50.—Diagram of fracture of external condyle by abduction of forearm.

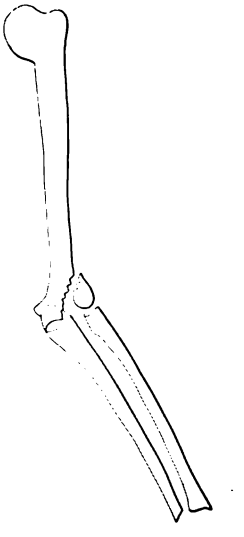


FIG. 51.—Diagram of fracture of external condyle by abduction of forearm.

were due to the greater injury exerted upon the outer side of the joint, owing to the natural tendency of all force transmitted from the forearm to the humerus to cause increase of the physiological *cubitus valgus*, as indicated in Fig. 51.

Thus the existence of the carrying angle accounts for the greater frequency, after falls on the outstretched hand, of fractures of the epitrochlea or rupture of the internal lateral ligament as compared with detachment of the epicondyle or rupture of the external lateral ligament; and in part for the greater frequency of fractures of the external condyle from the same injury, as compared with fractures of the internal condyle. In Case 9 a sudden increase of the cubitus valgus, by wrenching the

elbow between two upright bars, resulted in a partial supracondylar fracture, the line of fracture commencing above the internal condyle (on the side of extension as distinguished from the side of compression) and extending nearly all the way across the shaft.

2. The effects of *falls upon the flexed forearm* or *upon the acutely flexed elbow* are perhaps less difficult to analyze. If the patient lands

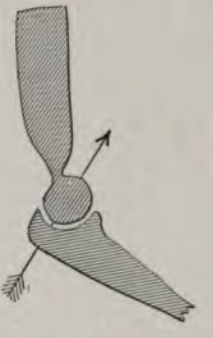


FIG. 52.—Diagram of action of force in causing diacondylar fracture. (After Chutro.)

FIG. 53.—Skiagraph of fracture of olecranon, external condyle, and neck of radius.

squarely upon the upper extensor surface of the ulna, he may acquire a fracture of the internal condyle, the impact driving the ulna against the trochlea and splitting the entire inner condyle off the humerus; but force received in this way is more apt to expend itself upon the ulna,

fracturing it and perhaps producing a forward dislocation of the radius. If the patient lands not solely upon the subcutaneous portion of the upper ulna, but upon the radius as well, the usual result is a transverse diacondylar fracture, with little displacement (Fig. 52); or sometimes an epiphyseal separation (Case 48). It has been claimed that falls upon the upper part of the ulna, with the forearm flexed to a right angle,

FIG. 54.—Skiagraph of fracture of olecranon and supracondylar fracture "by flexion."

may be a cause of fractures of the external condyle, the force being transmitted from the greater sigmoid cavity of the ulna to the outer lip of the trochlea, and thus detaching the external condyle. One case in my series (Case 36) has such a history; but it seemed to me that the injury was more likely to be due to direct violence, the fall having been on the outer part of the acutely flexed elbow, rather than upon the extensor surface of the flexed forearm.

Falls upon the acutely flexed elbow may cause fracture of either condyle or of both (supracondylar); and the lower fragment of the humerus may be detached in one piece or it may be comminuted. If the arm is abducted in falling, the patient will land more upon the inner surface of the elbow, and a fracture of the internal condyle will result, as in Cases 53 and 55. If, on the contrary, the arm is held close to the side in falling, so that the patient lands more upon the outer surface of the elbow, a fracture of the external condyle may result (Case 36). An interesting result of a fall on the flexed elbow is seen in Fig. 53; here there were produced fractures of the olecranon, of the external condyle, and of the neck of the radius. A supracondylar fracture "by flexion" usually is

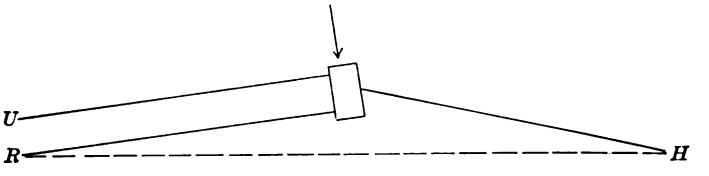



FIG. 55.—Diagram of fracture of external condyle by adduction of forearm.

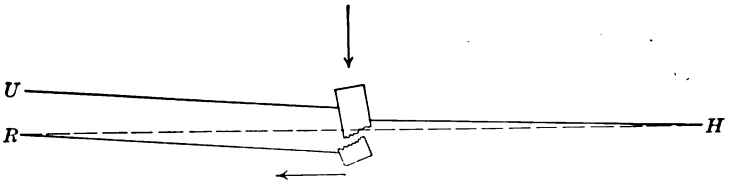



FIG. 56.—Diagram of fracture of external condyle by adduction of forearm.

produced in the same way, the olecranon process carrying the lower fragment of the humerus forward into the bend of the elbow. Fig. 54 shows such a fracture higher on the diaphysis than typical, and accompanied by fracture of the olecranon without displacement.

3. Still another injury may occur, the force being applied *directly to the outer side of the fully extended joint*, which is crushed between the body above and the ground beneath. In Case 8 such an injury caused a comminuted supracondylar fracture, the elbow feeling like a bag of bones. In Cases 38 and 40 fracture of the external condyle alone was produced in this way, either by direct violence (rare) or by adduction of the forearm, the shoulder and hand coming first into contact with the ground, and the weight of the body then forcing the elbow (the apex of a triangle, as in Figs. 55 and 56) into a straight line. Stimson and others have frequently produced such a fracture experimentally by adduction of the supinated forearm. Evidently the external condyle is torn off by the pull of the external lateral ligament.

## EXAMINATION OF THE PATIENT.

It is necessary in the first place to insist upon the surgeon making an intelligent and exhaustive examination of all injuries in the region of the elbow. The bad results seen arise almost exclusively from failure to recognize the injury, and hence to institute proper treatment, when the case is first seen. Too often a patient with a swollen and painful elbow has the part dressed with lead water and laudanum or some patent clay, the dressing being held in place by a bandage, in many cases not even a sling being applied. After some ten days or two weeks it is noticed that as the swelling subsides the elbow remains stiff, and injudicious attempts at massage and forced passive movements make the patient miserable, exasperate the mother, and usually dishearten the surgeon. The fracture was not reduced, callus is forming, arthritis persists, and the fault is the surgeon's for neglecting proper treatment at the proper time. As Kocher says, "Man hat entweder gut reponirt und bekommt gute Heilung, oder man hat schlecht reponirt und bekommt schlechte Heilung."

**History of the Injury.**—While the patient is being prepared for examination, the surgeon should inquire how the injury was received. He should learn the height of the fall, the positions of the arm, elbow, and hand, and, if possible, the *manner of landing;* he may ask about the position of the arm when first seen by by-standers; whether the bone was heard or felt to crack or grit; and in general learn everything about the injury which might have a bearing on the diagnosis. As will be seen subsequently, definite types of fracture usually result from certain injuries.

**Inspection.**—I make it an invariable rule to remove all the patient's clothes down to the waist, so as to be enabled to compare the appearance of the two arms, from wrist to shoulder. Note the position of the forearm (pronation or supination); of the elbow (flexed or fully extended); the presence or the absence of the carrying angle; the existence of abrasions or contusions of the part of the limb said to have come into contact with the ground. Observe the presence or absence of swelling around the elbow, its character and localization; whether confined to the region of the supinators, to the extensor surface of the forearm, extending along the flexor group of muscles arising from the epitrochlea, or limited to the flexure of the elbow. Ecchymosis and bullæ, the latter of which are rare, do not appear usually for twenty-four or thirty-six hours after the injury; and if the fracture is reduced promptly they seldom appear at all. Ask the patient to move the elbow if possible. In severe injuries around the elbow the whole upper extremity is moved from the shoulder

like a pump-handle, the elbow itself being held rigid. Only in injuries of extreme degrees does the elbow become flail-like.

**Palpation.**—It is always well to go from the known to the unknown; it is frequently useless to begin by palpating bony prominences around the elbow, since from the extent of the swelling it may be impossible to identify them in this way. Unless some definite method is followed, some important point is nearly sure to be overlooked. It is often well, especially in the case of children, to gain the patient's confidence by examining first the normal elbow.

In palpating the injured elbow, I divide the examination into two parts: (1) Palpation with the finger tips; (2) examination for crepitus, abnormal mobility, etc.

1. **The examination with the finger tips** invariably starts by running the fingers gently but firmly up the subcutaneous border of the ulna. This can invariably be found, and as invariably leads to the *olecranon*, a landmark directly at the elbow, and one which is easily distinguished from either condyle when located in this manner. The second step is to follow the radius up to its head, and to identify in this way the *external condyle*. When the olecranon and the external condyle have been positively identified, it is scarcely ever difficult, even in a much swollen elbow, to detect the *internal condyle*, which normally is easier to discover by palpation than is the external. But if the surgeon commences his voyage of discovery in the midst of the rocks and shoals around the elbow, he frequently will be considerably puzzled to decide which is internal condyle and which olecranon, or to be positive that the radial head and the external condyle bear a normal relation to each other.

Having identified the three bony landmarks of the elbow region, the surgeon must study their relation to each other. If this relation is normal the bones of the forearm are not dislocated backward, but the existence of a fracture is not excluded; if this relation is abnormal, a dislocation, a fracture, and rarely both, may be present.

Then carefully palpate the shaft of the humerus from above downward, as far as possible. In this way it is often possible to determine, in the presence of a fracture, that the upper fragment is projecting forward into the fold of the elbow.

Finally, every primary examination should include tests for paralysis or anæsthesia from injury of the nerves around the elbow, especially the ulnar and median distribution for sensation, and the radial (musculo-spiral) for motion.

2. **Examination for Crepitus, Abnormal Mobility, etc.**—Holding the shaft of the humerus firmly in one hand, the forearm should be grasped in the other. First gentle motions of flexion and extension should be made. Then the forearm, flexed to a right angle, should be thrust backward

and pulled forward on the humerus; in the case of supracondylar fracture (and in some others) the lower fragment, moving with the forearm, will produce crepitus as it slides back and forth on the upper fragment (shaft of the humerus). If this manœuvre fails to produce crepitus or to reveal abnormal mobility, the shaft of the humerus should be grasped tightly and an endeavor made to rotate the lower fragment of the humerus on the upper, using the bent forearm as a lever. Attempts should next be made to discover the presence of lateral mobility in the elbow, by fully extending the forearm and adducting and abducting it while the humerus is held rigid with the other hand; this test usually is positive in fractures of either condyle, as well as in most supracondylar fractures, while the earlier tests described rarely are positive except in supracondylar fractures.

If all the above tests give a negative result, or in cases where further confirmation of a suspected fracture of one or other condyle is desired, the surgeon should next grasp the condyles one in each hand, and endeavor to elicit crepitus by rubbing them together; or by pressing them together and suddenly releasing the pressure, sometimes a "tapping" sensation may be felt. If these final tests are positive, it next becomes necessary to prove which is the fractured condyle. This is done by proving that the other remains attached to the shaft of the humerus. If neither condyle is attached to the shaft, and there is motion between the two condyles, it is safe to diagnosticate an intercondylar (T or Y) fracture.

It may be thought that these manipulations and this somewhat tedious examination are not only unnecessary but undesirable. That they are necessary is best proved by the fact that even with the most painstaking and methodical examination a fracture is occasionally overlooked, either because impacted, or because the detached fragment lies entirely within the joint; but the more hasty and superficial the examination the more apt will other fractures be to go undetected. That these manipulations are not undesirable follows as a corollary of the last statement; and that they are actually desirable I think is clear when it is pointed out that a fracture impacted with deformity will be thus released, and reduction more easily accomplished. That damage can be done by rough handling is, of course, possible; but the fact that no damage ensued in the series of 56 cases herewith reported is certainly evidence that such an examination as advised can be made without rough handling. That this examination is painful to the patient cannot be denied; but it is not so painful in practice as it appears in print, and the paramount importance for prognosis of making a positive diagnosis at the earliest possible moment more than compensates the surgeon for his trouble and the patient for his suffering; for if an accurate diagnosis is made,

and proper treatment promptly instituted, both the surgeon's trouble and the patient's suffering will be short-lived; whereas, under contrary circumstances a deformed and painful elbow will long remain a sorrowful memento to the patient and an opprobrium to the art of surgery.

The question of the use of a general anæsthetic for the purposes of diagnosis and for reduction of the fracture is naturally raised at this point. Many surgeons at present are advising it as a routine measure. For my own part I have employed it in only three cases (Cases 8, 10, 20) for reducing the fracture, and never solely for diagnosis. These three cases were: (Case 8) a badly comminuted supracondylar fracture, the elbow feeling like a bag of bones; (Case 10) a diacondylar fracture "by flexion;" and (Case 20) an impacted supracondylar fracture, the skiagraphs showing that the first attempts at reduction, without an anæsthetic, had not been successful.

**Interpretation of Skiagraphs.**—Whenever possible, a skiagraph of the elbow should be made after the surgeon has concluded his routine examination, and before any attempt at reduction has been made. It might be still more desirable to have a skiagraph taken before any examination whatever were made; but it certainly would be highly objectionable for the surgeon to consider a physical examination unnecessary if a skiagraph was obtainable before one was made. But it is desirable to have an ocular demonstration of the lesions such as a skiagraph gives, if possible before any attempts to reduce the fracture are made. Unfortunately, it is rarely possible to secure the services of a skiagrapher at so short notice; so that the surgeon must base his tentative diagnosis and guide his treatment solely by the eyes which he has in the ends of his fingers. But at some later date, usually the next day at latest, a skiagraphic examination should be made, and the surgeon should study the plate before dressing the fracture again. When routine use of the X-rays is made in this way, the surgeon will find them a positive aid in making a diagnosis in other cases, even those where no skiagraphic examination can be made; he will learn what to look for, and knowing what to look for he usually will find it. In services where no X-ray apparatus is provided, the surgeon who has no experience with skiagraphic diagnosis elsewhere will let many an elbow injury go undiagnosticated or diagnosticated inaccurately; while he who is thoroughly familiar with the valuable information derived from a skiagraph of similar cases will be able to assert with certainty that the injury present conforms to a certain type.

Mere radioscopic inspection of an injured elbow should never suffice; the radiographic plate is a *sine qua non* for intelligent interpretation.

In making the radiograph the film side of the plate is placed next the patient's limb, and the picture etched on the plate is the shadow of those

parts impervious to the X-rays. In looking at the developed plate, if it is held with the film side toward the observer, he is in the position occupied by the Crookes tube when the exposure was made, and therefore is looking at the shadow of the elbow bones from the side of exposure. In making a photographic print of an X-ray plate it is customary, for the sake of getting better definition, to place the film side in contact with the photographic paper, so that the print of an X-ray plate is the reverse of the plate as ordinarily viewed. Thus, in making a skiagraph of the elbow in antero-posterior view, the posterior surface of the elbow is placed in contact with the film of the X-ray plate, and the skiagraph when developed will represent the elbow viewed from the front, if the plate is held up against the light with the film side toward the observer; if, however, the plate is observed with the film side *away* from the observer the elbow will appear *as if viewed from behind;* and prints made from this plate will represent the elbow viewed from behind. This is an important point to remember, as confusion easily arises if the observer forgets his own point of view. In making a lateral view of the elbow, the bone in contact with the film is more clearly defined than the other. Usually the inner side of the elbow is in contact with the film, so that the ulna and internal condyle are more clearly defined than the external condyle and the radius. But reversing a lateral view, as is done in printing, makes a much less noticeable change than does reversing an antero-posterior view. Yet it is well to remember that ordinary skiagraphic prints of lateral views of the elbow appear as if viewed from the inner side of the elbow. In the case of the skiagraphs reproduced in this work I have taken pains to indicate the observer's point of view whenever confusion seemed likely to arise.

## SUPRACONDYLAR FRACTURES.

There are 21 recent cases of this type in my series (Cases 1 to 21). It is the most frequent type, constituting 37.5 per cent. of the cases. The *age* of the patients varied from fourteen months (Case 7) to eleven years. No cases were observed in adults. During the same period of time (1903 to 1909), 9 cases of dislocation of the elbow were treated, 4 of which were in adults (aged thirty-seven, forty-five, forty-eight, and forty-nine years), and 5 in children (aged nine, twelve, twelve, fourteen, and fourteen years); thus, all but one of the children with dislocation of the elbow were older than the oldest patient with supracondylar fracture. As has already been pointed out (page 26), the bones in adults are stronger than the ligaments, so that falls causing sudden hyperextension of the elbow as a part of the injury are more likely to cause dislocation than fracture. Most fractures of the lower end of the

humerus in adults are from direct violence, the joint being crushed, caught in a revolving shaft, etc.; they are frequently compound, and operative treatment (amputation, removal of splinters, fixation) is often indicated. If not complicated by injury to the soft parts, a dislocation often co-exists.

**Mechanism.**—As the patients usually are children, they frequently are unable to tell how the injury was received; moreover, in a large dispensary service the mechanism of the injury, even if known, sometimes is not recorded. I find that among these 21 cases of supracondylar fracture there is no note how the injury was received, or it is recorded that the mechanism was "uncertain," in 5 cases; leaving 16 cases in which some statement as to the mechanism is made.

In 6 it is recorded simply as "from a fall" (presumably on the outstretched hand, which is the natural way for a child to fall). In 3 it is recorded specifically as "from a fall on the outstretched hand." In 1 (Case 11) the cause was a fall on the *flexor* surface of the forearm, causing hyperextension of the elbow. In 4 the cause was a fall on the *extensor* surface of the forearm, the elbow being flexed at about a right angle. In 1 (Case 8) the cause was a fall on the outer side of the elbow which was fully extended. This caused a comminuted fracture. In 1 (Case 9) the elbow was caught between the uprights of a balustrade.

It will be noted that in the first three groups, comprising 10 cases (6+3+1), the mechanism consisted in a thrusting force on the elbow in the long axis of the forearm, thus causing violent hyperextension of the elbow. That this (thrust + hyperextension) is the most frequent mechanism has been stated at page 51. It is surprising that in no less than 4 cases the fracture should have been caused by falls on the extensor surface of the flexed forearm. Experimentally such an injury has been found more apt to cause a transverse diacondylar fracture or even an epiphyseal separation; but even thus it is worthy of note that in two of these four cases in which the injury was caused by a fall on the flexed forearm the line of fracture was low, conforming very closely to the diacondylar type (Cases 12 and 18).

I have tried to produce a supracondylar fracture of the humerus in the (adult) cadaver by indirect violence:

1. By repeated blows with a heavy mallet on the overextended palm, with the elbow flexed at a right angle, and the condyles of the humerus projecting beyond the edge of the table. No fracture could be produced.

2. By blows on the overextended palm with the elbow fully extended. No fracture could be produced.

3. By blows on the sawed end of the humerus, the limb resting on the overextended palm and the elbow being fully extended. No fracture could be produced.

The typical fracture shown in Fig. 57 could only be produced by a blow on the extensor surface of the humerus above the condyles, the elbow being flexed at a right angle, and the limb resting on the over-extended palm. This really was by direct violence. I attribute the failure to cause a fracture by indirect violence partly to the inefficiency of the force employed (the bones were those of an adult, not a child), and largely to the absence of the hyperextension of the elbow which tears off the condyles. In children's cadavers this fracture is easily produced by simple hyperextension. Kocher records the case of a patient (adult man) who had a supracondylar fracture produced by

FIG. 57.—Experimental supracondylar fracture, at right angles.

simple hyperextension of the elbow, another man having placed the patient's elbow on his own shoulder and then attempting to raise the patient from the ground by pulling downward on his forearm.

**Symptoms.**—Apart from symptoms common to all fractures (pain, disability, tenderness, swelling, etc.), which need not be further discussed, the most important signs to look for are deformity, crepitus, and point of false motion.

The *deformity* somewhat resembles that of posterior dislocation of the elbow. The differential diagnosis of these injuries has been so often insisted upon, that it is useless to dilate upon it here; but I think Chutro does well to quote Dupuytren's advice "Si un médecin disait qu'il y a luxation et qu'un autre affirme qu'il y a fracture, on ne doit pas balancer

de suivre l'avis de ce dernier, parceque, dans cet opinion il ne laisse courir aucun chance de deformation, d'impotence, et des maladies consecutives." Not only is it true that the prognosis will be better in the case of a dislocation treated as a fracture than in that of a fracture treated as a dislocation, but it is a much more usual thing for a fracture to be considered a dislocation than the contrary. And it is particularly worth noting that supracondylar fractures often are accompanied by very slight (sometimes by no) deformity, and that owing to swelling it may be impossible to recognize deformity even when it exists. Frequently the only appreciable bony deformity will be a projection of the upper fragment in the bend of the elbow; if this projection is sharp and jagged, the injury is nearly certain to be a fracture above the condyles. In diacondylar fractures the upper fragment does not protrude so much, and is more rounded in contour. So that two things especially are to be remembered in regard to the deformity of supracondylar fractures: (1) In case of doubt as to the diagnosis of fracture or dislocation, incline to the diagnosis of fracture; (2) many injuries to the elbow without appreciable deformity will be found by their subsequent course to have been cases of fracture. In either case the injury should be treated as if it really was a fracture until the contrary is proved.

*Crepitus* is present with very few exceptions; but in impacted fractures, which are not very rare, it will not be obtained until the fragments have been released in the effort of reduction (Cases 18, 19, 20). The methods of eliciting crepitus in supracondylar fracture already have been alluded to (page 57): they consist in (1) movements of flexion and extension; (2) back-and-forth movements of the lower fragment on the upper, secured by manipulation of the forearm; and (3) in rotatory movements of the lower on the upper fragment. It is not necessary to secure crepitus more than once to assure one's self of its presence; the infliction of additional pain on the patient merely for the edification of by-standers is to be condemned.

A *point of false motion* can seldom be detected unless there is crepitus. It is best demonstrated by adducting and abducting the forearm with the elbow in full extension. As previously stated (page 58), this sign may be present in fracture of either condyle, and it is only by ascertaining that both condyles move with the forearm that the surgeon can conclude on the presence of supracondylar fracture.

**Pathological Anatomy.**—The direction of the fracture usually is from behind, downward and forward. As a consequence there is persistent tendency to backward and upward displacement of the lower fragment, which becomes tilted, the condyles being posterior, and the fractured surface more or less anterior. The displacement of the lower fragment is due (1) to the fracturing force; (2) to the action of the triceps, which

draws the olecranon backward and upward; (3) to the brachialis anticus and biceps, which draw the lower fragment upward; and (4) to the action of the muscles joining the lower fragment with the forearm and hand, all of which tend to rotate it forward around a transverse axis, and to keep it flexed on the bones of the forearm. These muscles (those arising respectively from the epitrochlea and epicondyle) are *the only muscles attached to the lower fragment.* Thus, it will be observed, *the lower fragment remains flexed in relation to the forearm;* and when the forearm is fully extended the lower fragment is tilted still more transversely by the tension on the muscles attached to the epitrochlea and

FIG. 58.—Experimental supracondylar fracture, in hyperflexion.

epicondyle. Only when the forearm is acutely flexed on this lower fragment (which can be controlled only through the medium of the forearm) will these muscles cease to be tense and to flex the lower fragment on the forearm (Fig. 58).

The periosteum on the posterior surface of the humerus is not always completely torn through, even in cases of supracondylar fracture with great displacement. Sometimes it is stripped up from the posterior surface of the humerus, but remains as a bridge passing from the displaced lower fragment up to the shaft of the humerus several inches above the line of fracture. Lusk has recently called attention to the

difficulty which this periosteal bridge offers to reduction. He has not noted, however, the fact that unless reduction is accomplished and the periosteum re-applied as nearly as may be to the posterior surface of the shaft of the humerus, the blood which is effused between it and the shaft will become organized, and by proliferation of the periosteum marked thickening of the shaft of the humerus will occur, with the result that complete reduction of the fracture very quickly may become impossible. Fig. 59, a skiagraph made ten days after a supracondylar fracture was received, shows a barely perceptible shadow passing from the displaced lower fragment up several inches before it joins the posterior surface

FIG. 59.—Skiagraph of supracondylar fracture, showing stripping up of periosteum, after ten days.

of the shaft of the humerus—this shadow being cast by the stripped-up periosteum, as is clearly demonstrated in Fig. 60, from a skiagraph made two weeks later. In Fig. 60 the shadows cast by the adhesive strips employed to retain the dressing may also be seen; but the newly formed subperiosteal bone casts a very distinct shadow, and binds the unreduced lower fragment in its position of backward displacement. When this girl (aged eight years) first came under my care (November 3, 1905), over five weeks after the injury, I found her with an elbow possessing only 15 to 20 degrees of motion, being nearly ankylosed at a right angle. Examination of the skiagraphs previously made (Fig. 59, made September 8, 1905, and Fig. 60, made September 22, 1905) showed the existence

of an unreduced supracondylar fracture, the arm having been dressed at a right angle on an anterior angular splint. In attempts at flexion the coronoid process of the ulna butted against the lower extremity of the upper fragment in the bend of the elbow, and extension also was impossible, probably from fibrous adhesions. The child was therefore etherized (November 3, 1905), and forcible movements of flexion and extension were made (arthrolysis); the gunstock deformity (*varus*) evident when the forearm was fully extended under the anæsthetic was corrected, the lower fragment being forcibly refractured from

FIG. 60.—Skiagraph of supracondylar fracture, showing stripping up of periosteum, after three weeks.

the upper. The corrected position is shown in Fig. 61, from a skiagraph made some days later, the elbow having been dressed in hyperflexion. This patient was kept under observation until September, 1907, at which date she had motion in the elbow from 60 to 110 degrees, the motion so far being perfectly free, but being checked abruptly in both flexion and extension, as if by bony contact. Operation was urged, but the parents thought the arm sufficiently useful as it was, since the child could now get her hand to her mouth. This case goes to show both the evil result of neglect to obtain accurate reduction of the fracture, and the futility of

arthrolysis as a remedial measure; the increased range of motion so obtained was only a little over 30 degrees.

Chutro (loc. cit., p. 232) describes a fracture closely resembling this, but classifies it apart from other supracondylar fractures as a "rare variety;" but it seems to me he has wrongly interpreted his skiagraphs as showing an upward splitting of the inner part of the humeral shaft. It is true that the skiagraphs convey this impression, and I was for a long time misled by the skiagraph of my own patient (Fig. 60) into thinking that in her case the shaft of the humerus had been split upward;

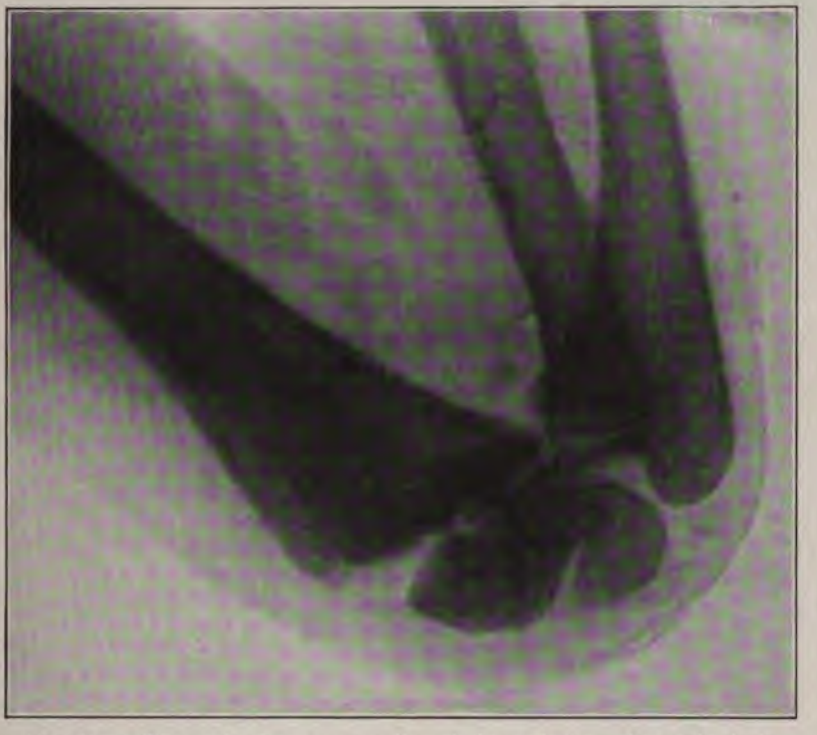


FIG. 61.—Skiagraph of same case, elbow in hyperflexion, after arthrolysis.

but when I had observed a number of other similar skiagraphs, made at varying periods after the fractures, and showing the progressive growth of the subperiosteal bone, I finally detected in Fig. 59 (on re-examination) a faint shadow undoubtedly cast by the periosteum itself; and this proved to my mind that the appearances in Fig. 60 were deceptive, and due solely to new bony outgrowth, and not to a splitting of the humeral shaft. This stripping of periosteum I have noticed in a number of my recent cases, in addition to that of the ancient fracture detailed above (Case 1, Fig. 71; Case 11, Fig. 84; Case 18, Fig. 94; Case 47, Fig. 136; Case 55, Fig. 149). It is a feature of fractures about the

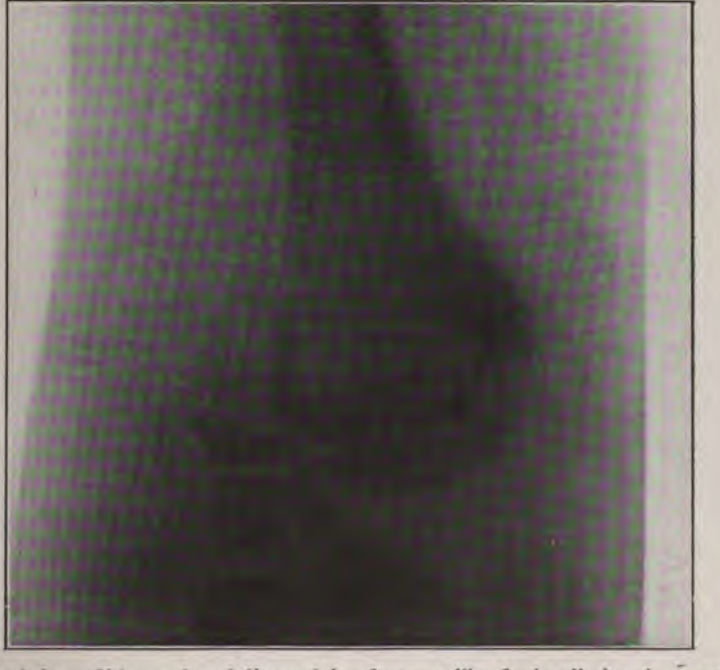
elbow which has not been sufficiently recognized. Even in *anterior* displacement of the lower fragment the periosteum may be stripped up from the anterior surface of the humerus, as shown in Fig. 62 (diacondylar fracture).

Forward displacement of the lower fragment (Kocher's fracture by flexion) was not encountered in the present series of supracondylar fractures, though it was seen in one case of diacondylar fracture (Case 24). As already noted, it is generally considered very rare. Mouchet has seen it only once among 78 supracondylar fractures. Yet Hilgenreiner records 8 fractures by flexion among 21 supracondylar fractures; but only 2 of these cases were in children. It should be borne in mind that forward displacement may not be the primary deformity, but that it may be produced by manipulation by by-standers or the surgeon himself, before an X-ray examination is made.

In any case, however, it is rare for the lower fragment to be displaced *directly* either forward or backward; a lateral deviation is not infrequent, and the fragment may also be slightly rotated on an antero-posterior axis, so that the external condyle is displaced downward and the internal upward, or even in the opposite direction. This must be remembered in reducing the fracture.

**Treatment.**—In supracondylar fractures, as in fractures in all other parts of the body, the indications for treatment are to reduce the fragments and maintain them in accurate apposition until consolidation takes place.

**Reduction** is accomplished with due regard to the displacement present and to the factors which produce it. The fragments are often more or less impacted, and much more force must be used to unlock them and secure reduction than is commonly believed. By hyperextension, traction in the long axis of the limb, and then by forced flexion into the position termed in this work *hyperflexion*, reduction is easily obtained in recent cases, and the good position secured is maintained by the aid of nature. *Hyperextension* of the elbow should be carried just sufficiently beyond a straight line to free the lower fragment from the upper, without causing the upper fragment to protrude so far in the bend of the elbow as to endanger the soft parts. This act of hyperextension momentarily increases the deformity by rotating the lower fragment on its transverse axis (page 64); this separates the fractured surface of the lower fragment from the shaft of the humerus, and by using the triceps and the bridge of periosteum (when it exists) as a hinge, permits the subsequent manipulations to be successfully carried out. Having thus relieved the impaction and freed the fragments, the surgeon presses backward on the shaft of the humerus (*counter-extension*) while he makes traction (*extension*) on the forearm, firmly and unhesitatingly bringing

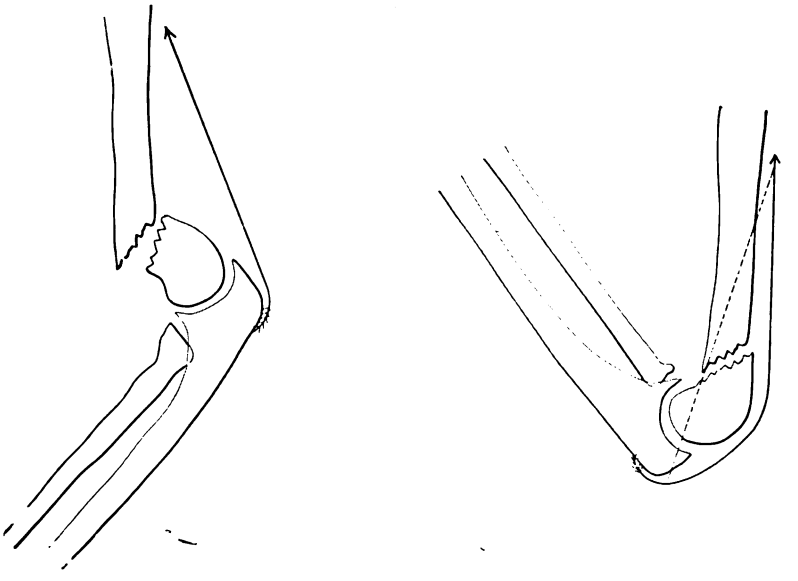


FIGS. 62 and 63.—Skiagraphs of diacondylar fracture "by flexion," showing periosteum stripped up from anterior surface of humerus.

it up into the position of hyperflexion, and taking care to maintain the ground previously gained by keeping up traction on the forearm until the angle between the forearm and arm has been decreased to at least 30 degrees. In bringing the forearm up toward the arm, the surgeon must be very particular not to rotate the lower fragment on the axis of the shaft of the humerus; if the lower fragment is rotated inward, by undue adduction of the forearm, *cubitus varus* will result; if it is rotated outward by excessive abduction of the forearm, *cubitus valgus* will result. In either case the relation of the articular surface of the humerus to the long axis of this bone will be changed, and, as pointed out at pages 28 and 29, this is the prime cause of distortions of the carrying angle. If the forearm is flexed in such a manner that its axis corresponds with that of the humerus, viewed in the sagittal plane (the humerus itself being rotated neither outward nor inward), the normal obliquity of the articular end of the humerus must be preserved (Figs. 16 and 17). In any case of uncertainty it is best to err on the side of too great abduction of the forearm, as *cubitus valgus* is a much less disabling and less conspicuous deformity than is *cubitus varus*.

**Retention.**—Having reduced the fracture, the next problem is to retain the fragments in proper position. As has already been pointed out (page 26), the position of hyperflexion is the position of greatest stability. It is best adapted for retaining the fragments of a supracondylar fracture in place for many reasons: The lower fragment is kept flexed on the forearm by the muscles attached to the epicondyle and epitrochlea; therefore, to prevent the original deformity from recurring, the forearm must be kept flexed at any rate to a right angle. But when the elbow is at a right angle, the triceps acts in a plane posterior to the axis of the humerus, so that it constantly tends to draw the olecranon, and with it the lower fragment of the humerus, backward (Fig. 64, *a*); when, however, the elbow is hyperflexed, *the point of insertion of the triceps is carried anterior to the longitudinal axis of the humerus*, so that the action of this muscle on the lower fragment is no longer in a plane posterior to that of the humerus, but tends to crowd the lower fragment directly into the place where it should be (Fig. 64, *b*). The triceps becomes very tense in the position of hyperflexion, and it passes down behind the condyles and around under them to its insertion on the subcutaneous portion of the olecranon precisely like a sling; and so long as the position of hyperflexion is maintained, with an intact triceps, *posterior displacement of the lower fragment is impossible*, while the direction of the fractured surface and the contact of the soft parts effectually guards against forward displacement. When the elbow is dressed at a right angle its position must be maintained by a splint of wood or of plaster. In this country a wooden splint is generally used, either an internal angular

(Physick's splint) or an anterior angular (Hartshorne's). With such a dressing it is exceedingly difficult to overcome the action of the triceps, which constantly tends to backward displacement of the lower fragment. Even bandaging the upper arm first to the vertical portion of the splint, and then keeping up traction on the forearm, as this part is bandaged to the horizontal portion of the splint, is rarely efficient in overcoming this backward displacement of the lower fragment. Coenen uses plaster of Paris, and while it is setting one assistant drags backward on the humerus through means of a sling, while another makes traction on the forearm, the patient being anæsthetized; he is quite satisfied with his



*a* *b*

FIG. 64.—Diagram to show action of triceps with elbow in extension (*a*), and in hyperflexion (*b*).

results, though his experience appears to be confined to 8 cases, 2 patients recovering with *cubitus varus*. The experience detailed and the skiagraphs reproduced in connection with the fifth case of my series (Figs. 75, 76, and 77) make clear the difficulty of retention at a right angle. Another objection to the maintenance of the elbow at a right angle on a splint is that rotation of the lower fragment on the upper, around a longitudinal axis, is not prevented; when the arm is first dressed the forearm is in the sagittal plane, but when it is put in a sling and carried against the body, it has rotated through an angle of fully 60 degrees, and when in the sling lies more nearly in the frontal than in

the sagittal plane. Now, in this rotation it is almost unavoidable for the relation of the fragments to be altered, as the shaft of the humerus is cylindrical, and any splint gets only a weak grip on it; so that it is too much to expect that the splint will rotate the upper fragment as much as it does the lower, which is firmly attached to the forearm by the lateral ligaments of the elbow. It was to avoid this very rotation that Dauvergne, in 1873, adopted the position of hyperflexion for the treatment of these injuries.

The fear of *gunstock deformity* (*cubitus varus* or *valgus*) led Allis, and after him Roberts, Lane, and others, to employ the position of complete extension, previously used by Pezerat (1832), Berthomier (1875), and advocated by Liston, Bardenheuer, Heusner, and others. While it is true that the carrying angle is evident only in full extension, it is not true, I think, that it cannot be preserved without resort to a position extremely irksome to the patient, and one which neither overcomes the posterior displacement of the lower fragment nor prevents its axial rotation on the upper. Moreover, should ankylosis occur (which I believe is vastly more probable in the extended than in the hyperflexed position), the arm will be in a position of all others the least to be desired.

It is most important to restore the articulating surface of the humerus to its normal anterior position (Fig. 1); even more important, I believe, than the preservation of the carrying angle; and inasmuch as hyperflexion of the elbow accomplishes the former better than any other position, and when properly employed insures the preservation of the carrying angle quite as well as does any other position, I earnestly advocate it as the best position for treatment of supracondylar fractures.

The dressing used to maintain the position of hyperflexion is described at page 88.

**Results.**—Of these 21 cases of supracondylar fracture, 4 (Cases 1, 6, 14, 16) cannot be traced; the only one of the four in which a perfect result was not anticipated was Case 14; this patient (aged five years) fell and again injured her elbow ten days after it was removed from the sling, and again a week later had her elbow injured for the third time in a trolley-car collision; when last seen, six weeks after her third injury, she had a range of motion from 75 degrees to 110 degrees, with no pain. This range of motion might be expected to improve considerably. Repeated efforts to learn her further history have been unavailing.

In one of the patients traced (Case 2), who was treated on an internal angular splint, slight loss of the carrying angle was noted over three years after the fracture for which I treated the patient; but as one year after she was under my care (two years before my final examination) she again fractured the same elbow, and was treated by another physician,

I am not entirely sure that the loss of the carrying angle is to be charged up to my account.

In the 16 other patients with supracondylar fracture the result must be classed as perfect—by which I understand no limitation of motion in flexion or extension, and preservation of the carrying angle. All these patients were treated in hyperflexion.

If, then, in 16 out of 21 cases (80 per cent.) the results are known to be perfect; if in three more the result is probably perfect (19 out of 21, or 90 per cent.); and if in the two cases where the result is not perfect (Cases 2 and 14) there exist extenuating circumstances in the nature of subsequent injuries, I think it may be asserted, with some show of truth, that a gloomy prognosis in cases of uncomplicated supracondylar fractures has no place in modern surgery.

## TRANSVERSE DIACONDYLAR FRACTURES.

There are 8 recent cases of this type in my series (Cases 22 to 29). Most surgeons make no distinction between this type and supracondylar fractures, though many, as Stimson, recognize a "low supracondylar fracture." Kocher records only one case among those published in 1896; this he represents in an illustration, giving the line of fracture approximately along the epiphyseal line, though he did not consider it a case of epiphyseal separation. As his illustration was made from the clinical findings alone, before the X-rays came into general use, it is possible that it does not accurately represent the condition present. In my own cases I have been inclined to class as diacondylar all transverse fractures distinctly above the epiphyseal line which nevertheless invade the joint. As will be seen subsequently, this type is distinct in its causation, as well as in its clinical course, from ordinary supracondylar fractures, so that the distinction seems to me well worth making.

**Mechanism.**—It is generally the case that transverse diacondylar fractures are produced by falls on the extensor surface of the forearm or the elbow, the shock knocking off a portion of the lower extremity of the humerus, which is impacted or is subsequently displaced by muscular action. Forward displacement of the lower fragment may be attributed to the continuation of the fracturing force, when this acts forward (by flexion); backward displacement to the fracturing force aided by the contraction of the triceps muscle. Unfortunately, in the only case in this series in which there was simple forward displacement of the lower fragment (Case 24) it is not known how the patient was injured, beyond the fact that the injury was caused by falling off a table; but such a fall is not so apt to be on to the outstretched hand as is one

which results from the patient's tripping while walking or running on the ground. In the fracture of the Posadas type (Case 28), the patient fell on the overextended hand, but to determine the further mechanism of the injury seems impossible; probably posterior dislocation occurred in the usual way by hyperextension of the elbow, and for some reason a diacondylar fracture was subsequently produced. When this rare injury is produced by a fall on the extensor surface of the partly flexed forearm, Chutro explains the mechanism in the following way: The force as originally applied causes a diacondylar fracture, with forward displacement of the lower fragment; the bones of the forearm accompany this as far as possible, but after a very slight excursion in this anterior direction the point of the olecranon strikes against the diaphysis of the humerus just above the line of fracture, the result being that the ulna, and with it the radius, is arrested sooner than the lower fragment of the humerus; subsequently, the triceps draws the ulna upward and backward, completing the dislocation.

Of the six cases in my series of the ordinary type of diacondylar fracture, the mechanism is not recorded in 2; in only 1 case did the fracture follow a fall on the outstretched hand; it followed a fall on the extensor surface of the flexed forearm in 2 cases, and a fall on the flexed elbow in 1 case. The mechanism in the latter three cases conforms to the usual type; and as noted at page 61 the fractures produced by this mechanism in Cases 12 and 18 so closely resemble diacondylar fractures that their inclusion among the supracondylar or in the present class is a matter of indifference.

**Symptoms.**—The symptoms of the ordinary diacondylar fracture resemble so closely those of the supracondylar that there is little to be added to what was there said. *Displacement* is less usual, owing to the mechanism, the smaller size of the fragment, and to its being partly, at least, intracapsular; *crepitus* is rather indistinct, and *mobility* is unusual. A positive diagnosis from supracondylar fracture can rarely be made without the use of the X-rays; and in many cases of injury to the elbow in which no fracture is detected clinically, the skiagraph, in either antero-posterior or lateral view (not always in both), will reveal the presence of a diacondylar fracture, with or without displacement. If there is displacement, a lateral view will be more apt to show it; if there is no displacement (Figs. 34 and 35), the fracture is best seen in antero-posterior views. The symptoms of the Posadas type are discussed sufficiently in connection with Case 28 (page 129).

**Pathological Anatomy.**—The line of fracture almost invariably passes through the olecranon fossa, being intracapsular at this point. The lower fragment often is more or less crescent-shaped, the epicondyle and epitrochlea being detached with the fragment and forming the horns

of the crescent, while the portion of the diaphysis between the olecranon fossa and the epiphyseal line forms the body of the crescent. This fracture has in some unaccountable way been confused by many writers with epiphyseal separation. If displacement exists it is more apt to be lateral (internal or external) as well as posterior than directly posterior. In 3 of my cases the lower fragment was displaced chiefly posteriorly, in 2 anteriorly (Cases 24 and 28), in 1 externally, and in 1 there was no displacement. In one case the displacement is not mentioned.

**Treatment.**—This is practically the same as for supracondylar fractures, and for the same reasons. Even if the lower fragment be displaced anteriorly, the position of hyperflexion will give the best results.

**Results.**—As the fracture is partly intra-articular, usually involving the thin shell of bone separating the coronoid and olecranon fossæ (Fig. 5), the results are not so good as in supracondylar fractures, which are entirely extra-articular. Of the six cases of the ordinary type of diacondylar fracture in my series, the result is classed as perfect in 5; in 1 patient (Case 23), though the patient has no deformity and full flexion, yet extension is limited to 165 degrees, the result therefore being imperfect.

The result in the case of diacondylar fracture by flexion is also imperfect, as a slight (barely perceptible) *cubitus varus* exists (Fig. 106), though flexion and extension are normal.

The patient with the fracture of the Posadas type (Case 28) secured perfect function, with full flexion and full extension; but in my anxiety to prevent *varus* deformity I succeeded in giving him a marked *cubitus valgus* (Fig. 115); but as in every other case of this type to which I have reference the result was nearly complete ankylosis in almost full extension, it has seemed fair to call the result in the present case *good*.

## FRACTURES OF THE EXTERNAL CONDYLE.

There are 12 such cases in my series (Cases 30 to 41). The *age* of the patients varied from two and one-half to twelve years. Some surgeons consider it a more frequent injury than the supracondylar variety.

**Mechanism.**—This is not recorded, or is uncertain, in 7 cases. A *fall on the outstretched hand* was the cause in 2 cases (Cases 32 and 35), the head of the radius impinging on the capitellum, as described at page 50, and hyperextension or abduction of the forearm perhaps aiding in producing the fracture (Figs. 50 and 51). One patient (Case 36) said she fell on the extensor surface of the flexed forearm; and, as noted at page 54, it has been claimed that fractures of the external condyle are produced in this way, the ulna breaking off the external lip of the trochlea when forced upward by contact with the ground. It has seemed more

likely, however, so far as I can see, that the injury is produced rather by a *fall upon the acutely flexed elbow*, the patient landing directly upon the external condyle, with the arm close against the body. Fracture by *adduction of the forearm* (Figs. 55 and 56), as described at page 55, was the cause in Cases 38 and 40; these patients fell to the ground, crushing the fully extended elbow between their body and the ground, causing great tension on the external lateral ligament, which thus produced a sprain fracture, as it were, of the external condyle. This may seem a strange explanation of the mechanism in these latter cases, as adduction of the forearm is quite apt to result in subluxation of the radius (pulled elbow), the external lateral ligament being attached not to the radius, but to the ulna, through the medium of the orbicular ligament. But as fractures of the external condyle are quite easily produced in the cadavera of children, experimentally, by simple adduction of the forearm, and as in the patients who sustain the injury in the manner described there is no evidence whatsoever of the fracture having been produced by direct violence (the only other mechanism possible under the circumstances), it seems to me not at all unreasonable to assign the injury to ligamentous action. The lateral ligaments are much stronger than surgeons generally suppose.

**Symptoms.**—Most conspicuous to *inspection* is localized swelling over the external condyle, and loss of the carrying angle. On *palpation* the epicondyle usually is found displaced downward and forward, and the region of the external condyle is much more sensitive than that of the internal. The fully extended forearm can be readily adducted and abducted at the elbow, producing alternate *cubitus varus* and *valgus*. *Crepitus* can be elicited sometimes by pushing and pulling the forearm back and forth, thus moving the external condyle on the shaft; but is more often to be detected by grasping the whole external condyle between the thumb and finger, and moving it fore and aft while the shaft of the humerus is held still by the other hand. In a few cases where the condyle has not been freely detached, I have succeeded in obtaining crepitus only by gently depressing the condyle against the shaft, when a slight tapping sensation was perceived. When all the above symptoms are present, and it can be ascertained that the internal condyle remains attached to the shaft, the diagnosis of fracture of the external condyle is certain even without resort to a skiagraph. To be of most value a skiagraph should show an antero-posterior view, although even an oblique view may suffice to confirm a doubtful diagnosis.

**Pathological Anatomy.**—The line of fracture invariably enters the joint; mere detachment of the extra-articular portion of the external condyle (termed here the epicondyle) I have never observed. The detached fragment includes the entire capitellum and usually the outer

lip of the trochlea. The only muscles attached to the fragment are those arising from the external condyle; the brachio-radialis and the extensor carpi radialis longior, which are attached also to the supra-condylar ridge, probably limit the amount of displacement. This displacement, as already noted under symptomatology, usually is downward and forward, due slightly to muscular action, but chiefly to the force of gravity, by which the forearm falls against the patient's side, as the normal support which maintains the carrying angle has been destroyed.

**Treatment.**—To replace the fragment in its proper position the forearm must be abducted, restoring the carrying angle; and the elbow must be flexed, thus forcing the external condyle backward. By bringing the forearm up into the position of hyperflexion, the external condyle is then held firmly in its normal position by the tense triceps behind it, and is prevented from being displaced forward by contact with the head of the radius which cannot be moved forward except by adduction of the forearm. The disability which follows the treatment of this fracture on an anterior or an internal angular splint, arises chiefly from this very fact, that adduction of the forearm (causing anterior displacement of the fragment) is not prevented. Moreover, when the elbow is flexed at a right angle, downward displacement of the external condyle is favored. Normally the radius is on a higher plane than is the ulna (Fig. 25); but when the support which the radius receives from its attachments to the humerus is destroyed, as is the case in fractures of the external condyle, the head of the radius, and along with it the condyle, will sag downward. Moreover, as pointed out by Allis, the use of an anterior splint, on the flexor surface of the forearm, will tend to force the radius down to the same level as the ulna. But in the position of hyperflexion the triceps and its fibrous expansion become so tense that the external condyle is held firmly in its normal position when once it has been replaced there (Fig. 58). The objections to the position of full extension are the downward pull of the muscles attached to the epicondyle, which is increased with the degree of the extension, the irksomeness to the patient, and the difficulty of maintaining the carrying angle against the force of gravity which constantly tends to make the forearm assume the same axis as the arm. Yet I must confess that I have never tried dressing these fractures in full extension, so that these objections on my part may be rejected as purely theoretical; but the results from hyperflexion have been so satisfactory, both to myself and the patients, that I have not thought it wise to experiment with a position which does not commend itself to me from the point of view of applied anatomy.

**Results.**—Eleven of my cases of fracture of the external condyle have been traced. In 10 the result is classed as perfect; in 1 (Case 33) there

is very slight limitation of extension, and scarcely appreciable *cubitus varus*. This patient did not apply for treatment until two days after the injury.

## FRACTURES OF THE EPITROCHLEA.

There are only 3 instances of this fracture in my series of recent injuries (Cases 42, 43, and 44). The ages of the patients were twelve, twelve, and fourteen years. I have seen a number of cases of old fractures of the epitrochlea, in addition to the three recent fractures, and think it must often be overlooked by the patient as well as by his physician. Mouchet encountered it in nearly 19 per cent. of his elbow injuries.

The epiphyseal centre for the epitrochlea leads a more or less independent existence, not uniting with the other epiphyseal centres, but joining directly with the diaphysis at about eighteen years of age; hence it is more liable to be detached up to this age.

**Mechanism.**—The injury usually is in the nature of a sprain fracture, the prominent tubercle being torn off by a sudden strain thrown on the muscles attached to it, and on the internal lateral ligament. In two of my recent cases the injury followed a fall on the outstretched hand, which caused hyperextension of the elbow and sudden abduction of the forearm at the elbow; in the third patient it followed a fall directly on the acutely flexed elbow, thus being caused by direct violence, or possibly being produced by an outward strain on the ulna which expended its force on the epitrochlea through the internal lateral ligament. In Case 44 posterior luxation of the ulna also was produced, as well as an injury to the olecranon; the latter probably occurred as a compression fracture, as the violent hyperextension of the elbow, causing the dislocation, crammed the olecranon into the olecranon fossa. The fracture of the olecranon certainly was not produced by direct violence, as the boy fell on his outstretched hand, and as it is inconceivable that posterior luxation of the ulna could be produced by a fall on the olecranon.

**Symptoms.**—Very little serious disability follows this injury, and it is often neglected, being treated as a sprain. On examination, besides localized swelling, and on the second or third day ecchymosis over the inner aspect of the elbow, the surgeon can readily detect the separation of the epitrochlea by its mobility, and by producing crepitus by rubbing this detached fragment against the shaft. The motions of the elbow-joint are not affected, though full extension is painful. Usually enough fibres of the internal lateral ligament remain intact to prevent any lateral mobility of the joint.

**Pathological Anatomy.**—The line of fracture is wholly extra-articular; if a portion of the internal lip of the trochlea is detached also, the injury

should be classed as a fracture of the internal condyle. There seems some reason to believe that in young children the capsule is not applied so closely to the base of the inner lip of the trochlea as it is in later life, so that sometimes it may be possible for a simple detachment of the epitrochlea to open the joint.

The fragment is displaced downward and forward by muscular action. Injury to the ulnar nerve is rare.

**Treatment.**—Immobilization in flexion probably is sufficient. I employed hyperflexion in all my cases.

**Results.**—The patient who also had his elbow dislocated cannot be traced; one patient recovered with full flexion and extension to 175 degrees (practically complete); the carrying angle was not altered; while in the third patient the result is classed as perfect. I have noticed that though return of complete extension is very slow even in patients who have been treated well, it is very much slower in those who have not been treated at all while the injury was recent.

## EPIPHYSEAL SEPARATIONS.

There are 7 such cases in my series (Cases 45 to 51). The *ages* of these patients were two, two, three, nine, eleven, eleven, and twelve years. That separation of the lower humeral epiphysis cannot occur except under the age of three years, "when it is still entirely cartilaginous," though it is a statement repeatedly made by Mouchet, I think cannot go unchallenged. In the first place the epiphysis is *not* "still entirely cartilaginous" until the age of three years, since the centre for the capitellum invariably appears before the end of the first year of life; and I think the diagnosis in my patients (Cases 45, 47, 49, and 50), whose ages varied from nine to twelve years, sufficiently exact to show that such an injury can occur even when ossification in the epiphysis is moderately far advanced. The question of diagnosis will be discussed with the symptoms.

The extraordinary number of epiphyseal separations (nearly one-fourth of the entire number of elbow injuries) seen by Chutro is a matter of surprise; several of the patients whose histories he relates in detail are over three years of age (five, six, eight years).

**Mechanism.**—This was not known or is not recorded in 4 of my patients. One patient fell on to the extensor surface of his flexed forearm, and two patients fell on to their outstretched hands; in one of these latter the fall produced momentary hyperextension of the elbow, but in the other the elbow collapsed into acute flexion.

**Symptoms.**—These resemble those of a severe sprain of the elbow, with something more which it may be difficult to recognize as an entity.

Chutro quotes the statement of O. Wolff: "Manche angebliche Contusion des Gelenkes würde besser unter der Diagnose Epiphysenlesion geführt."

I have not observed the rounded projection of the upper fragment in the bend of the elbow, described by so many writers as characteristic of epiphyseal separations, though sometimes the bend of the elbow has seemed fuller than normal. In the cases I have seen there has been no apparent displacement, and no clearly defined abnormal mobility; and I have based my diagnosis on (1) the severity of the subjective symptoms; (2) the persistent localized tenderness, especially apparent in the bend of the elbow; (3) the existence of moist crepitus; (4) extreme pain on forced extension, which pinches the fragments in their displaced position; and (5) on the results of skiagraphy. The skiagraph will exclude any other injury to the humerus, and in some instances will give positive evidence of an epiphyseal separation by showing a small shell torn off the diaphysis just above the epiphyseal line. For it is not unusual for such a shell of bone to be torn loose with the cartilage (Figs. 43, 134, 140). When the line of separation passes entirely through cartilage, as it frequently does, it will not be visible in a skiagraph, as the cartilage bordering the line of fracture will be quite as pervious to the X-rays as the line of fracture itself (page 42); in such a case the diagnosis must be made from the clinical symptoms alone. Thus in Case 48 the skiagraph showed absolutely no abnormality; and if the clinical symptoms had been disregarded the injury would have been classed as a sprain. But the subsequent development of *cubitus valgus* confirmed the clinical diagnosis by showing that there had been a severe injury to the epiphyseal cartilage.

**Pathological Anatomy.**—The reason that this lesion is more frequent among young than older children is that as age progresses the diaphysis grows downward toward the epiphysis, especially in the region between the centres for the capitellum and the trochlea, as noted at page 32 (Fig. 22); the consequence being that the epiphysis is strengthened by this spur of bone which grows down into it, and is therefore less liable to be torn loose.

The detached fragment is wholly or in large part *intra-articular*. The joint cavity, as seen in Fig. 5, extends to *above* the coronoid and radial fossæ; while the epiphyseal line lies distinctly below this point, a shell of the diaphysis separating it from these fossæ (Fig. 18). If the epitrochlea and epicondyle are detached along with the cartilage which goes to form the trochlea and capitellum, then the detached portion will be partly intra- and partly extracapsular.

Displacement usually is slight, as the capsule is not widely ruptured. The injury partakes more of the nature of a recent case of "internal

derangement of the knee-joint" where a piece of the articular cartilage has been chipped off by sudden and abnormal pinching between the ends of the bones.

**Treatment.**—The hyperflexed position has been employed in all my cases, though I do not think it so important in these as in supracondylar and transverse diacondylar fractures. Immobilization at a right angle probably would answer as well, but is not so comfortable to the patient; and some motion is apt to persist in the elbow-joint except when it is in hyperflexion.

**Results.**—Of the 7 patients, 2 cannot be traced; the result in 4 is classed as perfect; while in 1 patient (Case 48), though flexion is complete, extension is limited to 170 degrees, and there is slight *cubitus valgus*.

## FRACTURES OF THE INTERNAL CONDYLE.

There are only four cases of this injury in my series (Cases 52 to 55). The *ages* of the patients were two, fourteen, seventeen, and forty-two years, including two out of the three adults in the entire series, the third adult (Case 56) having suffered an intercondylar fracture. It is one of the rarest injuries around the elbow-joint. Chutro saw it only twice among 106 cases, and Mouchet only once among 170. Kocher observed 6 fractures of the internal condyle among 45 fractures of the lower end of the humerus, but in two the diagnosis was uncertain. In two of my own cases the diagnosis is not positive, as I have no notes of the symptoms, and no skiagraphs demonstrating the nature of the injury; one of these patients (Case 52) came under observation only two weeks after the injury.

Owing to the teaching of Allis, and afterward to the work of Davis, it was long believed that this was one of the most frequent fractures; but as both these observers based their opinion on the great number of cases of gunstock deformity they had seen, it was merely assumed that the preceding injury in most of the cases had been fracture of the internal condyle. Cotton contended, and I believe with perfect justice, that supracondylar fracture was the chief cause of subsequent gunstock deformity; not because fractures of the internal condyle are not exceedingly prone to give rise to this deformity, but simply because the total number of supracondylar fractures observed so greatly exceeds those of the internal condyle alone. Cotton in his own series of 32 cases had none of fractures of the internal condyle; yet he obtained 11 cases of cubitus varus, and 1 of cubitus valgus, among 27 cases traced. Coenen had 7 cases of varus and 1 of valgus among 28 cases of supracondylar fracture which he traced. Hilgenreiner, among 14 supracondylar fractures traced, found 4 with *varus*, and 1 with *valgus* deformity.

**Mechanism.**—This is not noted in the two cases in which the diagnosis is uncertain; in both the other patients the injury was received by a fall on the point of the acutely flexed elbow. Evidently either the ulna came into contact with the ground, and, impinging on the trochlea, split off its inner lip and the epitrochlea all in one piece, or else the fracture was produced by direct violence acting on the epitrochlea; the former is certainly much more probable. This is generally admitted to be the most frequent mechanism; and as children usually fall upon the outstretched hand, the rarity of this injury is easily explained.

**Symptoms.**—There usually is loss of the carrying angle, the weight of the forearm causing it to swing inward at the elbow, like a pendulum, when the support of the internal condyle is removed. Crepitus is easily detected by adduction and abduction of the forearm, and by moving the internal condyle antero-posteriorly on the shaft of the humerus. The injury to the soft parts frequently is more severe than in the usual run of elbow fractures.

**Pathological Anatomy.**—The line of fracture invariably extends into the joint, passing from above the epitrochlea (on the internal supracondylar ridge) down to the trochlear surface of the elbow-joint. If the epitrochlea alone, or the trochlea alone, is detached the lesion should not be classed as a fracture of the internal condyle; for although the trochlea and epitrochlea are parts of the internal condyle, to speak of such lesions as fractures of the internal condyle without qualifying the expression in any way is as misleading as it would be to classify fractures of the nasal bones among fractures of the skull.

The line of fracture may enter the joint just to the radial side of the prominent inner lip of the trochlea, as in Case 53 (Fig. 145), or in the middle of the trochlea, as shown in Fig. 44, or even in the neighborhood of the capitellum.

This probably is the most disabling of fractures around the elbow. The ulna is the main constituent of the forearm, being the anatomical continuation of the humerus, while the radius belongs to the hand. Consequently, fracture of the internal condyle, interfering with the continuity between the humerus and ulna, practically abolishes the functions of the forearm. The further the line of fracture extends toward the capitellum the more completely does the elbow assume the character of a ball-and-socket joint (page 21), the forearm swinging freely in all directions—forward, backward, inward, and outward.

When the forearm is flexed for examination, the fragment usually is found to be drawn forward by the muscles attached to it; but in the extended position downward displacement is not noticeable, as the weight of the forearm causes loss of the carrying angle, and the consequent

adduction of the forearm is rather inclined to force the internal condyle upward.

As the fracture usually is caused by great violence, axial rotation of the fragment is not unusual, and injury of the ulnar nerve may occur. This injury should be looked for when the patient is first examined; if discovered only at the second dressing, the patient may suspect that the ulnar paralysis was caused by the surgeon in setting the fracture, or by the form of dressing employed. In Case 53 complete rotation of the fragment occurred, but there was no trace of injury to the nerve. In some cases the fracture is subperiosteal, and no displacement exists (Fig. 45).

FIG. 65.—Skiagraph of old fracture of elbow, showing *cubitus varus* from ascent of internal condyle (antero-posterior).

**Treatment.**—I have treated all my patients in the position of hyperflexion. *Ascent of the fragment* is the chief obstacle with which the surgeon has to contend; and if ascent of the fragment is present, loss of the carrying angle will result, as the articular surface of the humerus will lose its normal obliquity, and will come to lie in a plane at right angles with the long axis of the bone, or in severe cases will even incline inward.

In the fully extended position ascent of the fragment is caused by the force of gravity, which adducts the forearm. It is true that this may be prevented by the use of a suitable splint, applied to the anterior surface of the fully extended limb, and made to conform to the natural carrying

angle. But even thus the constant tendency is for the forearm to be adducted, causing the humeral portion of the splint to deviate outward as the forearm portion is carried inward. Moreover, displacement from muscular action is favored, because the fragment is not fixed against the shaft; the muscles attached to the epitrochlea tend to rotate the fragment around a transverse axis, thus keeping it flexed on the ulna; and if the forearm is in any position except that of full flexion the action of the triceps will displace the fragment if its relation to the sigmoid cavity of the ulna is preserved. Dressing the forearm in full extension

FIG. 66.—Skiagraph of old fracture of elbow, showing upward displacement of ulna (lateral).

tends to make the internal condyle grow fast to the humerus "end on;" the normal anterior projection of the articular surface (Fig. 1) will not be preserved.

Dressing the elbow on a splint at right angles is, if possible, still more objectionable than the extended position. When an anterior angular splint is applied, as pointed out by Allis, it tends to bring the bones of the forearm into the same plane. In discussing fractures of the external condyle it was noted that this dressing tended to depress the radius, and with it the external condyle, to the same level as the ulna; in the case of fractures of the internal condyle the radius is the fixed point

of support, and both bandages and sling tend to elevate the ulna, and with it the internal condyle, to the level of the radius. Figs. 65 and 66 show these alterations very well. Fig. 65 is an antero-posterior view of an old fracture of the lower end of the humerus in which the trochlear surface of the humerus has assumed a higher position than the capitellum, with the resulting *cubitus varus* shown in the skiagraph; Fig. 66 is the lateral view of another old fracture of the lower end of the humerus, in which marked *cubitus varus* resulted, owing to the ascent of the ulna, which is seen in the skiagraph to occupy a higher plane than does the radius (compare Fig. 24).

Moreover, when the elbow is dressed on an anterior or on an internal angular splint the forearm is more or less in the sagittal plane when the dressing is applied; but when it is rotated inward so as to be carried in a sling, it is quite possible for the relation of the internal condyle to the shaft to be so altered as to give rise to subsequent deformity.

In the position of hyperflexion, on the contrary, the internal condyle cannot *ascend*, because it has the whole weight of the forearm acting on it through the ulna to hold it down; it cannot be displaced *backward* because the tense triceps guards against this; and in this position the flexor group of muscles is relaxed so that no rotation of the fragment around a transverse axis need be feared. The triceps, in this, as in all the fractures of the lower end of the humerus so far considered, acts as the best splint, surrounding the internal condyle behind, and below; and, by its insertion into the ulna and by its fibrous expansion to the external condyle and forearm, supports it also laterally and anteriorly. It is important, however, in applying the dressing to maintain the elbow in hyperflexion, to take care that it is applied while the arm and forearm maintain their normal relations as regards the sagittal plane (Fig. 17). If the humerus is kept in the anatomical position (rotated neither externally nor internally), and the forearm is then flexed upon it in the sagittal plane and is then bandaged to the humerus in that position before the hand is slung around the neck, there will be little chance of causing *cubitus varus*.

If replacement of the fragment is impossible by manipulation, an incision should be made, the fragment replaced and held in place, if possible, by periosteal sutures. Operative treatment is also indicated in cases of primary injury to the ulnar nerve.

**Results.**—My first patient (Case 52) cannot be traced. The second (Case 53) recovered with full flexion, extension to 150 degrees, and slight *cubitus valgus*, as seen in Fig. 146. The third patient (Case 54), a child of two years, in whom the diagnosis is uncertain, recovered with perfect functions and no deformity; while in the last case the result was equally good.

## INTERCONDYLAR FRACTURES.

From a personal experience of only one atypical case (Case 56) it is impossible to say much of this rare variety of fracture. I have seen a number of so-called T-fractures under the care of other surgeons, but have never been able to satisfy myself by personal investigation that the injury really was such as diagnosticated.[1]

**Mechanism.**—It usually is caused by direct violence, with considerable injury of the soft parts. It is possible that the ulna may act as a wedge in falls upon the flexed forearm, splitting the condyles off the shaft (Madelung's theory). Gurlt held that a supracondylar fracture was first produced, and that the diaphysis of the humerus then acted as a wedge in driving the condyles apart.

**Symptoms.**—The fracture often is compound, and the patients usually must be confined to bed for some days at least. It is least rare in adults. Owing to the condition of the soft parts and the extraordinary amount of swelling, palpation is of limited value; but in typical cases the breadth of the elbow is much increased, the condyles having a marked tendency to be separated by the shaft of the humerus, which sinks in between them. The ulna may seem to ascend between the condyles. A lateral skiagraphic view showing the upward displacement of the ulna gives a typical picture. Chutro reproduces one such skiagraph. Crepitus is readily detected, and the joint is more or less flail-like.

**Pathological Anatomy.**—From the descriptions given of these rare fractures, it is evident that while the type conforms in general to the T, Y, or V-shape, yet the fragments often are irregular in outline, and the displacement varies so much that no definite description of it can be given.

**Treatment.**—In many cases operative treatment is indicated. By means of two lateral incisions the integrity of the ulnar and radial nerves can be ascertained, loose splinters removed, and the condyles fixed by periosteal sutures, or even by long nails (Roberts).

In simple cases (those which can be treated without operation), I should be inclined to prefer any position (except full extension) which seemed to hold the fragments best in place. Some surgeons recommend the position of hyperflexion, but it should be remembered that where both condyles are broken off the tension put upon the triceps in that position will only drive the shaft of the humerus more deeply between the condyles, except in the case of a true T-fracture, when the end of

[1] Since writing the above, I have examined one case of T-fracture (diagnosis confirmed by skiagraph) under the care of my colleague, Dr. E. G. Alexander, at the Episcopal Hospital.

the humerus is fractured transversely. Perhaps employing an anterior angular splint with weight extension just below the elbow might suffice to keep the condyles down where they belong, though it certainly would be apt to give rise to gunstock deformity; but after all, this is a less evil than a stiff elbow.

In the only case under my care, which was at first diagnosticated as fracture of the internal condyle, the position of hyperflexion was used; an antero-posterior skiagraph (Fig. 150), made three weeks after the injury, showed also an impacted fracture of the external condyle.

**Results.**—In the case under my care full flexion and extension were present at the end of three weeks, but there was slight gunstock deformity. It has been impossible to trace this patient farther. Certainly, in typical intercondylar fractures the prognosis should be guarded; for, though a fair range of motion may be obtained, it is almost impossible to prevent a certain amount of deformity.

## COMPLICATIONS.

The chief complications encountered in fractures of the lower end of the humerus are Volkmann's ischæmic contracture, injuries to the nerves, especially the ulnar and median, and occasionally lesions of the blood-vessels. The only complication met with in the present series of 56 cases was a neuritis of the median nerve (Case 11), due to its being stretched over the projecting end of the upper fragment. This was relieved by operation, the projecting bone being chiselled off, and flaps of fascia sutured beneath the nerve. Among 31 cases of supracondylar fracture Coenen observed three cases of musculospiral paralysis; this has also been seen by Chutro. Mouchet has observed cases of ulnar paralysis occurring in adults, due, he thinks, to the gradual increase of a *cubitus valgus* resulting from a fracture of the external condyle in childhood. Destot, Vignard, and Barlatier, among 72 elbow fractures, observed one case each of musculospiral and of median paralysis, both patients recovering without operation; they say (p. 155) that Broca and Mouchet reported 9 cases with nerve injury among 78 elbow fractures, and that Müller claimed that nerve complications occur in one-fifth of cases of supracondylar fracture.

Coenen had one case of ischæmic contracture among his 31 recent supracondylar fractures. Several instances of this deformity have come under my observation, following fractures of the elbow treated by others. As noted recently by J. J. Thomas, nerve changes are almost always present as well, and the condition is difficult to distinguish from cases of ulnar neuritis.

Vascular lesions and other serious injuries of the soft parts are seldom observed unless the fracture is compound.

I have seen two cases of ununited fracture of the external condyle. Sir Astley Cooper (*Dislocations*, Plate XXV) gives an illustration of such a lesion.

## DRESSING THE ELBOW IN HYPERFLEXION.

The term *hyperflexion* is employed in this paper because it has been objected to the term "acute flexion" that any angle less than a right angle was acute, and that the term therefore was not sufficiently descriptive of the position advocated by Jones, of Liverpool, and others. According to Chutro (loc. cit., p. 158), it was Dauvergne who, in 1873, first suggested the position of hyperflexion for fractures of the lower end of the humerus. He urged flexion so acute that the hand touched the shoulder of the injured arm; in this way, he argued, the bones of the forearm themselves acted as an anterior splint, and he considered none other necessary. About fifteen years ago the position began to be known by the names of Jones and of Smith. Mr. Jones, so far as I have been able to ascertain, received the idea from his late master, Hugh Owen Thomas, who had employed the position of acute flexion after excisions of the elbow for tuberculous disease. H. L. Smith was also an early advocate of this position for fractures about the elbow.

A very usual mistake, I find, is to confuse Velpeau's position with that which I prefer to call *hyperflexion*. In the former, the hand of the injured extremity reposes *on the opposite shoulder*, and the elbow is flexed to approximately 45 degrees; this certainly is "acute" flexion. But in the position of *hyperflexion* the forearm is flexed upon the arm as far as it will go without causing arrest of the radial pulse; the hand of the injured extremity frequently can be brought to its own side of the neck; and always the thumb of the hand should be able to lie comfortably on the same side of the neck as the injured limb. In hyperflexion the elbow is at an angle of 30 degrees or less, sometimes at 20 degrees; this depends somewhat upon the amount of subcutaneous fat, œdema, etc. I have never seen a recent uncomplicated fracture of the lower end of the humerus in which the swelling was so great as to prevent the employment of this position.

It gives me pleasure to take this opportunity to thank Dr. J. H. Gibbon, who was at the time (1900) my chief at the Children's Hospital of Philadelphia, for first calling my attention to "Jones's position" in the treatment of these injuries. At the time I was skeptical of its value. Further experience, and especially an application of increasing anatomical knowledge to the injuries observed, has demonstrated to my

satisfaction its superiority over any other position; and in consequence I have been able to treat such fractures with a confidence and satisfaction, both to patients and surgeon, which I had previously believed to be unattainable.

To maintain the position of hyperflexion I employ nothing but a roller bandage. A fold of lint, with some dusting powder, is placed in the crease of the elbow, to prevent maceration of the apposed surfaces, and any abrasions, bullæ, etc., are suitably dressed. Then the fracture is set, by combined hyperextension, manipulation, and traction, as indicated, and with the humerus in the anatomical position the forearm is hyper-

FIG. 67.—Dressing to maintain elbow in hyperflexion, first stage.

FIG. 68.—Dressing to maintain elbow in hyperflexion, second stage.

flexed upon the arm exactly in the sagittal plane, or inclining slightly outward (abduction of the forearm), as I regard *cubitus valgus* as less of an evil than *cubitus varus*. The forearm is now held precisely in this position, regardless of whether its bones are supinated or pronated, and the application of the roller bandage is commenced, after ascertaining that the radial pulse has not been obliterated. Starting with several circular turns around the wrist, the hand is next carefully covered in; I have seen neglect of this precaution, in cases treated by other surgeons, lead to alarming swelling of the unsupported hand. When the roller again reaches the wrist, it is carried directly across to the upper arm,

as close as possible to the axilla, and, passing under and around the arm, is again returned to the wrist (Fig. 67). This first turn around the arm may be drawn fairly tight, as the precaution to commence the bandage by several turns around the wrist has placed a pad of such thickness over the ulna that injurious pressure on its subcutaneous surface need not be feared. Neglect to commence the bandage by sufficient circular turns around the wrist, in one case of which I have knowledge, resulted in a slough forming at this point. The bandage is then continued as shown in Fig. 68, covering in the elbow as an amputation stump. The humerus may be freely abducted from the body during the bandaging, when once

FIG. 69.—Dressing to maintain elbow in hyperflexion, completed.

the forearm has been fixed to it by one or two circular turns, as thereafter no movement in the elbow can take place whether the humerus is moved or not. Finally, the surgeon returns the roller to the wrist, and, without cutting the roller, bandages the wrist to the neck by one or two turns, internal rotation of the humerus and forearm *en masse* taking place as this manipulation is accomplished (Fig. 69). If one roller bandage is not sufficient, use two; it is always better, in fractures, to use too many bandages than too few; and, as long ago taught by Hippocrates, the outer bandages may be applied more snugly than the primary roller.

*The elbow and arm are never bandaged to the chest.* The child may wag its immovably fixed elbow all it wants to, abducting and adducting

the humerus as much as it pleases; *it cannot disturb the position of the fragments without first overcoming the hyperflexion.*

An undershirt may be slipped under the bandaged elbow; and by abducting the arm the axilla is freely opened for washing, powdering, etc. The back of the neck, if irritated by the bandages, may be protected by a piece of lint, folded to make a collar, the bandages being passed through safety-pins as the reins pass through the terrets on the horse's harness; usually washing the neck with alcohol, and the use of a dusting powder, makes such devices unnecessary.

The patient, or, if a child, his caretaker, is cautioned to observe the fingers from time to time, and to report any swelling at once. I have never had any inconvenience on this account. Invariably the patient is seen the next day after setting the fracture, but if the dressing is comfortable it is not disturbed. So often I have observed pain and swelling subside in a few hours after dressing these fractures in hyperflexion, that it ceases to be a surprise that patients prefer this position to the use of a right-angled splint.

On the third or fourth day after the injury the bandage is cut, and while the position of hyperflexion is carefully and unremittingly maintained by the surgeon, the hand, forearm, arm, axilla, and elbow are thoroughly washed with alcohol; then the hyperflexion is cautiously diminished just enough to enable the surgeon to bathe the flexure of the elbow and to insert a new piece of lint. The hyperflexion is then reproduced, and the roller bandage applied as before.

The elbow is dressed twice weekly, and the position of hyperflexion is maintained for over two weeks. Then the degree of flexion is gradually diminished at each dressing, no splint ever being used, but extension beyond 65 or 70 degrees being prevented by a figure-of-eight bandage around the elbow; and the wrist is still suspended from the neck. At the end of four weeks the extension has reached 90 degrees, and the arm is carried in a large triangular sling, preventing further extension for a week longer. At the end of five weeks the sling is discarded, and use of the arm is encouraged. Passive movements are never enforced. Occasionally, by abducting the humerus to a right angle and allowing the forearm to hang vertically downward, it is swayed gently back and forth as a pendulum; but no direct passive motion is employed, nor massage.

Some patients secure complete extension in the sixth week (Cases 8, 9, 55); others do not secure it for six months or a year (Cases 6, 22, 36). They are encouraged to carry weights in the hand, to use the arm in climbing, gymnastics, etc. By the use of the goniometer (Fig. 70) accurate records of the gradually returning extension may be kept, and the patient's interest in returning periodically for observation is

stimulated. This instrument should also be used in recording the final results.

If accurate replacement can be secured, and if the periosteum has not been too widely stripped from the bone, there is no reason to fear the development of excessive callus. No such callus is formed in fractures of the base of the skull, nor in other fractures without displacement. Long-continued immobilization of a normal joint has been proved, experimentally and clinically, not to be productive of ankylosis. If, therefore, the surgeon is confident that he has reduced a fracture of the lower end of the humerus, a fact which can be proved by the use of the X-rays, there is no reason why he should torture his patients by enforcing passive motion. As a resident physician in the hospitals, some

FIG. 70.—Goniometer.

of my chiefs "believed in the use of early passive motion" for fractures around the elbow; and many is the elbow on which at their instigation I have enforced violent passive movement with the idea of preventing or of breaking up adhesions, destroying or wearing away exuberant callus, etc. The children kicked, screamed, and yelled; their parents, the orderly, and the nurse held them still, while I gave them excruciating pain, and unwittingly aroused more osteogenetic and inflammatory processes around the elbow than were present before; and I never saw an elbow fracture which did not stiffen up under this treatment. Fractures around the elbow I regarded as hopeless; I anticipated a stiff joint, deformity, or at least a considerable limitation of motion in practically every case, and I rarely failed to find it.

Since then my eyes have been opened, and I am convinced of the truth of Stimson's epigrammatic statement: "If you leave the arm alone, you save your time and the patient's time, and he gets well quite as promptly."

## RESULTS.

The most disabling result of fractures of the lower end of the humerus is ankylosis; then in lessening degree come grades of restriction of motion just short of absolute ankylosis, up to a mere loss of the power of full extension and full flexion, which really hinders the functional use of the joint not at all. So long as a fair range of motion (say from 50 to 150 degrees) is preserved, there is comparatively little disability. Deformity, as such, is rarely disabling; marked degrees of gunstock deformity, especially *cubitus varus*, usually weaken the joint, and thus impair its functions, besides making the patient conspicuous. Slight degrees of deformity, especially *cubitus valgus*, are neither evident to the casual observer, nor do they interfere with the normal use of the joint, so long as its motility is preserved.

A *perfect result*, as the term is here used, implies one in which the full range of normal motion is preserved (*flexion* as in the uninjured elbow, and *extension* to at least 180 degrees), and in which the carrying angle is normal.

Judged by these standards the following results have been reported by various careful investigators: Coenen traced 28 supracondylar fractures of the humerus; he found a perfect result in 7 (25 per cent.), defective or limited motion in 6 (21.4 per cent.), marked limitation of motion in 6 (21.4 per cent.), *cubitus varus* in 7 (25 per cent.), and *cubitus valgus* and Volkmann's ischæmic contracture in 1 case each.

Cotton traced 27 patients with various fractures of the lower end of the humerus: a perfect result was secured in 5 (18.5 per cent.), moderate limitation of motion in 5 (18.5 per cent.), marked limitation of motion in 5 (18.5 per cent.), *cubitus varus* in 11 (40.74 per cent.), and *cubitus valgus* in 1 patient (3.7 per cent.).

Destot, Vignard, and Barlatier report the end results in 39 patients with fractures of the lower end of the humerus as follows: A perfect result (under which term they include all cases with full flexion and extension, regardless of whether or not there is *varus* or *valgus* deformity) in 11 cases (28.2 per cent.); marked impairment of function, including *varus* and *valgus* deformities, in 28 cases (71.8 per cent.).

Hilgenreiner traced 14 patients: in 3 (21.3 per cent.) of these a perfect result was secured; in 4 (28.57 per cent.) there was marked limitation of motion; in 4 (28.57 per cent. there was *cubitus varus;* in 1 (7 per cent.) there was *valgus;* and in 2 (14 per cent.) a flail-joint resulted.

In the present series of 56 patients it has been possible to ascertain the end results in 47 cases. These are shown in the following table:

END RESULTS OF FORTY-SEVEN CASES OF FRACTURE OF THE LOWER EXTREMITY OF THE HUMERUS.

| Fracture. | Cases. | Traced. | Perfect. | Limited motion. | Varus. | Valgus. |
|---|---|---|---|---|---|---|
| Supracondylar | 21 | 17 | 16 (94.0%) | | 1[1] | |
| Diacondylar | 8 | 8 | 5 (62.5%) | 1[2] | 1[3] | 1[4] |
| External condyle | 12 | 11 | 10 (91.0%) | .. | 1[5] | |
| Epitrochlea | 3 | 2 | 1 (50.0%) | 1[6] | | |
| Epiphyseal separation | 7 | 5 | 4 (80.0%) | 1[7] | | |
| Internal condyle | 4 | 3 | 2 (66.6%) | 1[8] | | |
| Intercondylar | 1 | 1 | .. | .. | 1[9] | |
| Total | 56 | 47 | 38 | 4 | 4 | 1 |
| Percentage of those traced | | | 81% | 8% | 8% | 2% |

These results are compared with those previously noted in the following table:

| Author. | Number of cases. | Number traced. | Results. Perfect. | Limited motion. | Cubitus varus. | Cubitus valgus. | Volkmann's ischæmic contracture. | Flail joint. |
|---|---|---|---|---|---|---|---|---|
| Author of essay | 56 | 47 | 38 (81.0%) | 4 ( 8%) | 4 ( 8%) | 1 (2.0%) | | |
| Coenen | 31[10] | 28 | 7 (25.0%) | 12 (43%) | 7 (25%) | 1 (3.0%) | 1 | |
| Cotton | 32 | 27 | 5 (18.5%) | 10 (37%) | 11 (40%) | 1 (3.7%) | | |
| Destot, Vignard, and Barlatier | | 39 | 11[11](28.2%) | 28[12](71.8%) | | | | |
| Hilgenreiner | 21[10] | 14 | 3 (21.3%) | 4 (28.5%) | 4 (28.5%) | 1 | .. | 2 |

[1] Case 2 sustained another fracture (diacondylar) two years after being under my care, but before final result was noted.

[2] Case 23. Full flexion, but extension only to 165 degrees.

[3] Case 24. Diacondylar fracture "by flexion." Full flexion and extension; *cubitus varus* scarcely appreciable (Fig. 106).

[4] Case 28. Fracture of the type "Posadas" (Fig. 115).

[5] Case 33. Full flexion, extension very nearly complete; very slight *cubitus varus*. Did not apply for treatment until two days after injury.

[6] Case 43. Full flexion, extension to 175 degrees.

[7] Case 48. Full flexion, extension to 170 degrees; slight *valgus* (Fig. 138).

[8] Case 53. Full flexion, extension to 150 degrees, and slight *valgus* (Fig. 146).

[9] Case 56. Full extension, but slight *cubitus varus*.

[10] Only supracondylar fractures.

[11] Includes *varus* and *valgus* deformities, with full flexion and extension.

[12] Includes *varus* and *valgus* deformities, with limited motion.

In the present series there were no cases of ankylosis; the greatest limitation of motion was a loss of 30 degrees in extension (in a case of fracture of the internal condyle); and there were no cases of ischæmic contracture. One patient (Case 11) developed a median neuritis, which was promptly relieved by operation. Several of these patients had such extensive injury of the soft parts when first seen that it was not deemed advisable to treat them as out-patients, and I am indebted to my chiefs for permission to attend them in the wards so long as it seemed expedient to keep them in the hospital.

As there appears to have been no difference in the severity or character of the lesions in these various series of cases (so far, at least, as one can judge from a study of the published case histories and skiagraphs), it is not unreasonable to suppose that the much better results obtained in the present series depend in some measure upon the treatment employed.

Possibly the views held by Destot, Vignard, and Barlatier, as to reduction of these fractures, may be shared by other surgeons, and may be partly accountable for the bad results obtained. Speaking of supracondylar fractures, these authors ask (loc. cit., p. 176): "Faut-il reduire d'emblée? La question ne se pose pas dans les cas où l'enfant vient au deuxième ou troisième jour apres son traumatisme. Le gonflement est au maximum et le mieux est de reduire et d'immobiliser ensuite. Si la fracture est très recent et date à peine de quelques heures, il est preferable d'attendre deux ou trois jours. Le gonflement, d'abord intense, tend à diminuer, on peut alors mettre un appareil definitive sans craindre qu'il n'exerce sur le membre des pressions trop fort." It has seemed to me, on the contrary, that the most important thing, if the case was seen early enough, was to place the fragments in accurate apposition, and by doing this to *prevent* the development of excessive swelling. I can see no object in postponing the reduction of a fracture when no swelling is present; and it certainly has been true in my experience that those fractures which are properly reduced within a few hours of the injury run their course without the development of marked inflammatory reaction in the soft parts; and I have noticed, time and time again, even after the soft parts had become greatly swollen before reduction was secured, that there was no way to relieve the patient's pain and to cause a diminution of the swelling so sure and certain as complete reduction of the bony deformity.

Some of the observers above cited have employed splints, some have used plaster-of-Paris bandages, and in a few instances the elbows have been treated in acute flexion.

The three perfect results in Hilgenreiner's series were all obtained after dressing the elbow in the position of acute flexion; the usual dressing was of plaster of Paris, with the elbow at a right angle, and though

he calls the results obtained by it *satisfactory* ("zufriedenstellende"), I think this term is open to criticism when it is borne in mind that he considers limitation of motion of from 20 to 90 degrees, as well as *varus* and *valgus* deformities with an equal restriction of motion, all as being satisfactory results.

Coenen advocates anæsthetization of the patient, and the application of a plaster-of-Paris bandage or splints with the elbow at an obtuse angle, two assistants being employed to correct the deformity while the plaster hardens, one by extension on the forearm, the other by counter-extension on the humerus by means of a sling. He treated a series of ten patients by this method, and calls the results "nearly ideal;" yet in the series thus treated there were two cases of *cubitus varus*, and one in which flexion was limited 10 degrees.

Destot, Vignard, and Barlatier generally used plaster of Paris, and prefer it to splints. For supracondylar fractures they prefer the position of acute flexion; yet of 25 supracondylar fractures recorded, a perfect result was secured in only 11, and *no perfect results* were obtained in 14 cases of other varieties of fracture. What they call "good" results were secured in 22 cases all told, including 8 cases of supracondylar fracture; but among good results they include cases of limited motion.

Cotton concludes that for fractures of the external condyle the best position is acute flexion; for supracondylar fractures he prefers to dress the elbow at right angles on an internal angular splint, and after two weeks to extend the elbow to 135 degrees, to discover whether or not there is gunstock deformity; if there is, he thinks it may still be successfully corrected after this lapse of time. He employed the position of acute flexion in only 10 of his cases; and in only one of these (Case 3) was it known that a perfect result had been obtained. As in several of these cases (Nos. 19, 20, 24) flexion was limited after recovery, and as several of his skiagraphs show the fracture still unreduced, with the elbow in acute flexion, it is evident that by the term acute flexion he does not understand the same position which is here called hyperflexion; since it is practically impossible to put the elbow in hyperflexion unless the fracture has been reduced.

In the present series of cases the position of hyperflexion was employed routinely, because it is the one position in which (in the overwhelming majority of cases) the fragments are retained accurately in place without the aid of pads, splints, etc. The patients were all treated in very busy out-services, and did not receive a disproportionate amount of attention; but the aim was to reduce the fractures at the earliest possible moment, to ascertain by means of the X-rays that reduction was complete, to maintain the fragments in accurate apposition until consolidation occurred, and then to leave the elbows alone, for function to be restored by active

movements by the patient himself. The low percentage of cases in which *cubitus varus* resulted (8 per cent., compared with 25, 28, and 40 per cent. of other observers), clearly demonstrates the fact that if reduction is successfully accomplished and maintained there is no need to extend the forearm on the arm to guard against the occurrence of this deformity.

But the mere position of hyperflexion is not in itself a panacea; as Destot, Vignard, and Barlatier very justly remark (loc. cit., p. 171): "The attitude of the forearm is of no consequence except as it permits the maintenance of the fragments in a more or less good position. If complete extension is the only position which permits the maintenance of reduction, one should not hesitate to give this position to the forearm." Nor do I deny that it is *possible* to maintain the fragments in place by the aid of splints, plaster casts, weight extension, etc., in some position other than that of hyperflexion; or that good results are not sometimes obtained by such methods (more by good luck than good management, however); but what I do believe is that a position which by anatomical factors mechanically maintains the fragments in place after reduction has been secured, and the routine employment of which produces the satisfactory results here recorded in a fairly large series of fractures usually (but I believe erroneously) accorded a very gloomy prognosis, is one which deserves wider recognition than it at present enjoys.

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# CLINICAL HISTORIES

## SUPRACONDYLAR FRACTURES.

1. **Supracondylar Fracture of Right Humerus.**—October 13, 1903. Harold E., aged 6 years. From fall. *Symptoms* not recorded. Skiagraph (Fig. 71), made October 14, 1903, shows internal and posterior displacement of lower fragment, and stripping up of periosteum. *Treatment* not recorded. No further notes.

*Result.*—Not traced.

FIG. 71.—Case 1. Skiagraph of supracondylar fracture.

2. **Supracondylar Fracture of Left Humerus.**—January 12, 1904. Katy H., aged 2 years. From fall. *Symptoms:* Crepitus, mobility; no deformity. *Treatment:* Internal angular splint, with arm bound to side of chest. Two weeks later developed measles and was dressed at home thereafter by family physician. Full extension was obtained one week after removal of splint; parents did not notice any loss of carrying angle.

On March 21, 1905, had another fall, injuring the same elbow. Skia-

graph (Fig. 72), made then, shows recent fracture just above epiphyseal line (transverse diacondylar fracture), and slight thickening above condyles, from previous supracondylar fracture. The patient was not under my care at the time of this second injury. In the skiagraph the centre for the capitellum of humerus is seen below external condyle, its shadow overlapping that of upper end of ulna. Between capitellum and shaft of humerus is a shell of bone (belonging to diaphysis), which has been fractured by recent injury.

FIG. 72.—Case 2. Skiagraph of old supracondylar, recent diacondylar fracture.

*Result.*—Examined April 28, 1907. Extension and flexion complete, also supination and pronation. There is slight gunstock deformity, the external condyle being prominent and displaced a little anteriorly; this makes the carrying angle about 190 degrees, the forearm falling about 10 degrees to the ulnar side of the axis of the humerus. This deformity may be due to the first fracture, as by the use of an internal angular splint it is usually impossible to prevent inward rotation of the

lower fragment. But as the child was not examined until two years after the second fracture, it is not impossible that the deformity should be attributed to it.

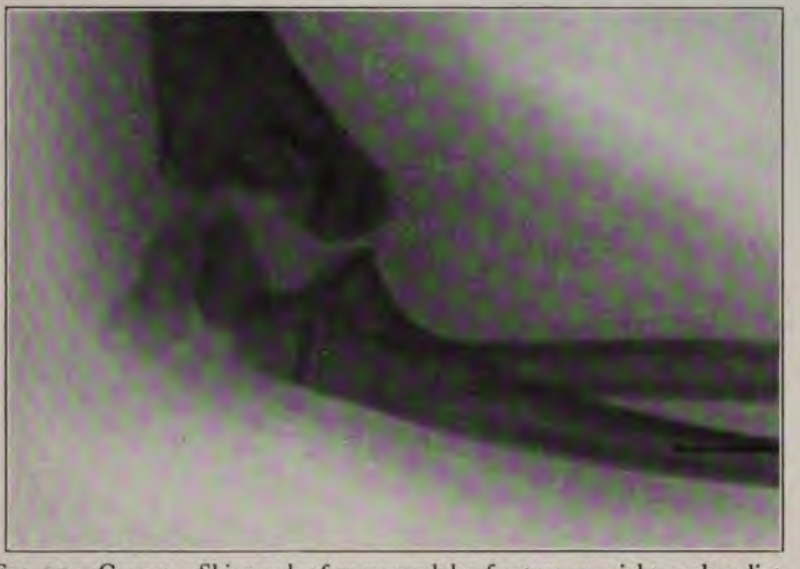

FIG. 73.—Case 3. Skiagraph of supracondylar fracture, on right-angle splint.

FIG. 74.—Case 3. After hyperflexion.

3. **Supracondylar Fracture of Left Humerus.**—November 27, 1904. Ella McG., aged 9 years. Fall on overextended palm. *Symptoms:* Swelling, pain, tenderness, crepitus, and mobility. *Treatment:* Resident physician applied an internal angular splint. Skiagraph (Fig. 73), made eighteen hours later, showed lower fragment still posterior, and tilted upward by action of triceps, and flexed on forearm by muscles attached to epitrochlea and epicondyle. At next visit, therefore (the third day

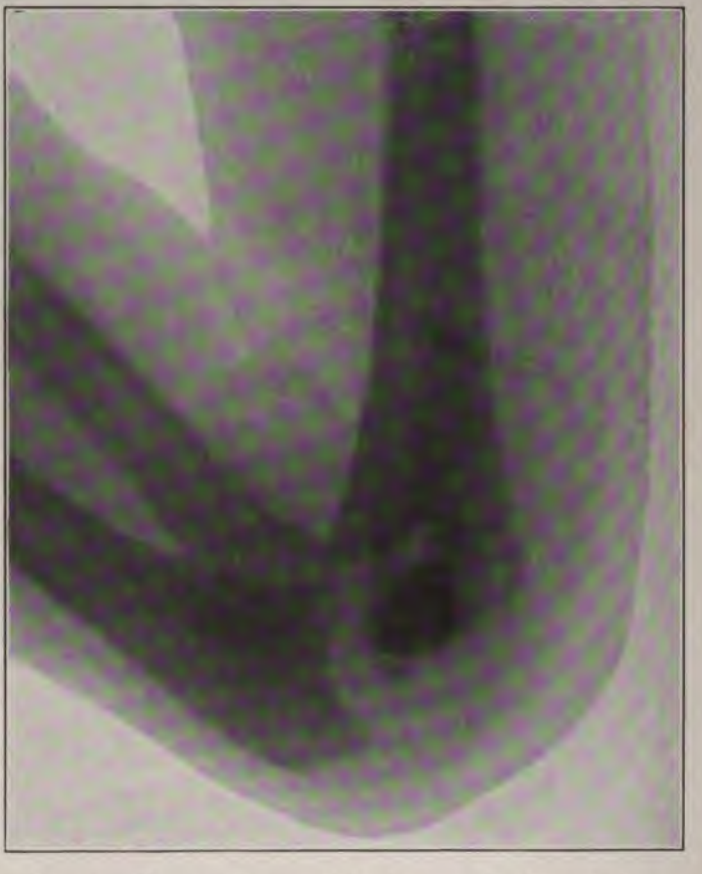

FIG. 75.—Case 5. Supracondylar fracture after hyperflexion.

after the injury), the elbow was hyperflexed, the excellent position obtained being shown in Fig. 74, from a skiagraph made on the fourth day of treatment. In third week elbow was dressed at right angles, and at the end of fourth week the forearm was carried in a sling without any dressing.

*Result.*—By the end of sixth week flexion and extension were complete, carrying angle was normal, and all functions were perfect.

4. **Supracondylar Fracture of Left Humerus.**—August 27, 1904. Harry R., aged 3 years. From fall. *Symptoms* not recorded. *Treatment:* Hyperflexion.

*Result.*—Examined April 27, 1907. Full extension, obtained a few days after stopping treatment; full flexion; carrying angle normal. Perfect result.

FIG. 76.—Case 5. At right angles.

5. **Supracondylar Fracture of Right Humerus.**—October 30, 1905. Joseph T., aged six years. From fall. *Symptoms* not recorded. *Treatment:* Dressed on internal angular splint by resident physician, on account of great swelling. Next day I dressed elbow in hyperflexion, in spite of swelling. Skiagraph (Fig. 75), made after this dressing, showed good position. On November 1, on account of swelling, the resident again dressed it on internal angular splint; he was skeptical of the value of the position of hyperflexion at any rate. Patient did not return until November 6; skiagraph made this day, with elbow still on internal angular splint, showed customary deformity of recent fracture (Fig. 76).

November 8, I again set the fracture, keeping fragments in position by the position of hyperflexion. Fig. 77, from skiagraph made November 9, shows very satisfactory position obtained. This fracture was not again dressed by the resident.

FIG. 77.—Case 5. Again in hyperflexion.

*Result.*—Examined December 29, 1905. Full flexion, and extension to 170 degrees (practically complete); carrying angle normal. It has been impossible to trace this patient longer than for two months after his injury; almost certainly he now has absolutely complete extension, and the result may be considered perfect.

6. **Supracondylar Fracture of Left Humerus.**—November 10, 1905. Marie F., aged two years. From fall. *Symptoms:* No deformity, but crepitus and mobility. *Skiagraph* (Fig. 78), made same day, is very indistinct, but shows posterior displacement of lower fragment. *Treatment:* After ascertaining result of skiagraph, elbow was dressed in hyperflexion.

*Result.*—This patient cannot be traced.

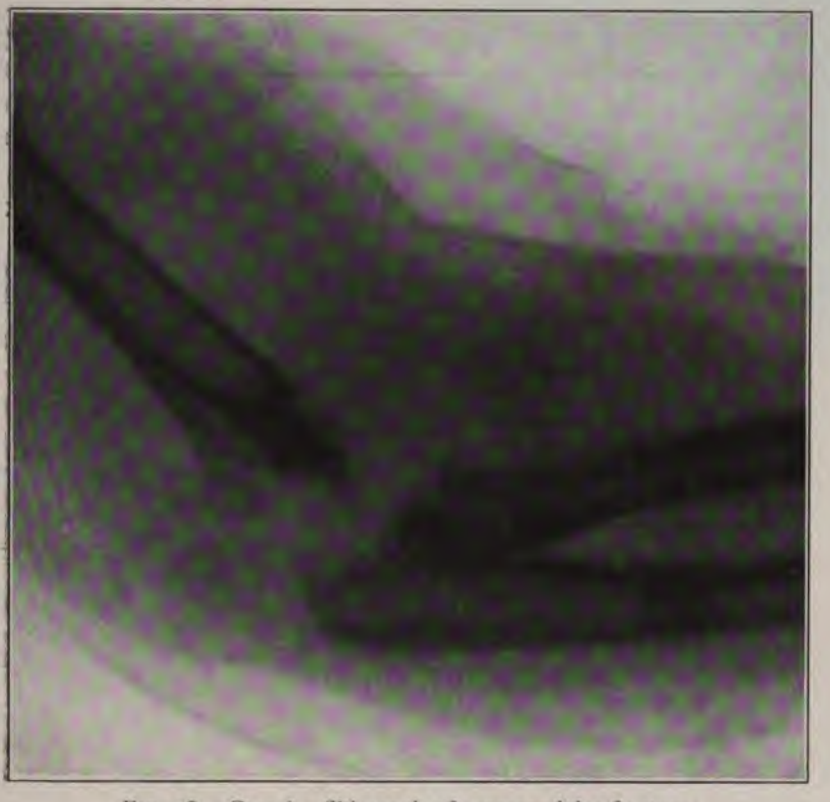

FIG. 78.—Case 6. Skiagraph of supracondylar fracture.

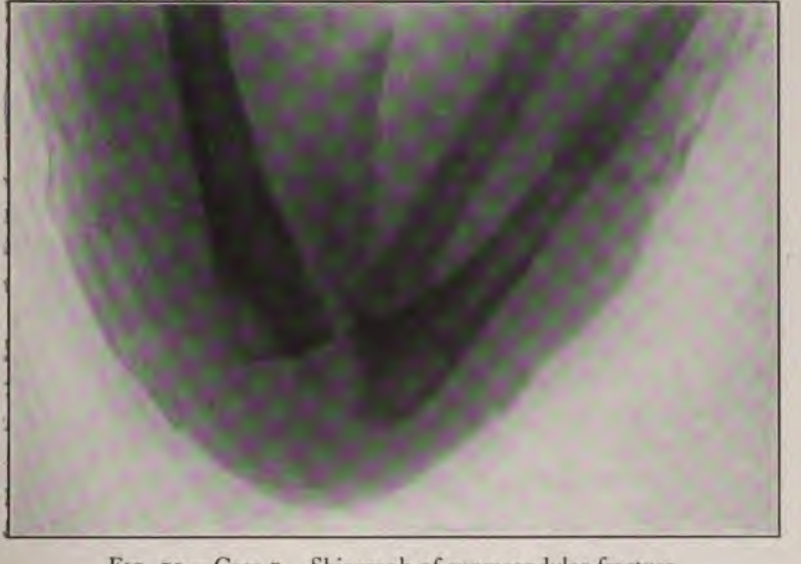

FIG. 79.—Case 7. Skiagraph of supracondylar fracture

7. **Supracondylar Fracture of Left Humerus.**—November 12, 1905. Stanley H., aged fourteen months. From fall. *Symptoms:* Crepitus, mobility back and forth above condyles. *Treatment:* Hyperflexion. Skiagraph (Fig. 79), made after setting fracture, shows perfect reduction, line of fracture passing across humerus about half an inch above epiphyseal line.

*Result.*—Examined December 19, 1905. Full flexion and extension, carrying angle normal. Perfect result.

FIG. 80.—Case 8. Skiagraph of comminuted supracondylar fracture.

8. **Comminuted Supracondylar Fracture of Left Humerus.**—December 19, 1905. Benny G., aged eight years. Pushed down by another boy, falling on outer side of elbow and forearm. *Symptoms:* Considerable localized swelling below internal condyle; joint very mobile, almost flail-like; crepitus; loose fragment, easily movable beneath skin, above internal condyle. *Treatment:* Etherized; motion very free, including adduction and abduction of elbow; fragments manipulated into position by direct pressure and by alternate flexion and extension of elbow. Dressed in hyperflexion. Skiagraph (Fig. 80), made next day, shows various fragments in good position. December 22, first dressing; no pain since first night. January 19, full flexion and almost complete extension; carrying angle normal.

*Result.*—June 8, 1907. Saw mother, who says there is full flexion and full extension, and that elbow is normal in every way. Perfect result.

9. **Supracondylar Fracture of Left Humerus.**—July 12, 1906. Joseph B., aged seven years. Made mis-step on stairs, caught left arm in bannisters. *Symptoms:* Great localized swelling and tenderness; no crepitus, no mobility. Skiagraph (mislaid) shows partial supracondylar fracture from above internal condyle half-way across shaft toward external condyle. *Treatment:* Hyperflexion. August 8, in sling. August 14, out of sling.

*Result.*—Examined August 28, 1906. Extension complete, flexion complete; carrying angle normal. Perfect result.

FIG. 81.—Case 10. Photograph showing full flexion after recovery from supracondylar fracture.

10. **Supracondylar Fracture of Left Humerus.**—July 16, 1906. Josephine K., aged four years and a half. From fall on street; it is not known how she landed. *Symptoms:* Marked mobility, crepitus, posterior displacement of lower fragment. *Treatment:* Hyperflexion. August 20, in sling. September 20, discharged.

*Result.*—Examined August 22, 1907. All functions normal. Right elbow (never injured), flexion, 25 degrees; extension, 187 degrees; carrying angle, 165 degrees.

Left elbow (fractured), flexion, 30 degrees; extension, 192 degrees; carrying angle, 167 degrees.

Figs. 81 and 82, from photographs made this day, show the result.

11. **Supracondylar Fracture of Left Humerus.**—September 22, 1906. Frank F., aged eleven years. Thrown down in a fight, landing on anterior surface of extended forearm, and suddenly hyperextending elbow. Taken to near-by physician, who dressed elbow on internal angular splint. Came under my care next day. *Symptoms:* Pain, swelling, tenderness, crepitus, and mobility; no injury to nerves noted. *Diagnosis:* Supracondylar fracture. *Treatment:* By extension and counter-extension, and by hyperextension of elbow, lower fragment was unlocked from shaft, and then by sudden and forcible flexion elbow was brought into hyperflexed position, and thus dressed. Skiagraph (Fig. 83), made

FIG. 82.—Case 10. Photograph showing full extension after recovery from supracondylar fracture.

September 22, shows fracture very nearly reduced. At the next dressing an effort was made to draw the lower fragment still farther forward. October 19, in sling. October 23, out of sling. November 15, extension to 100 degrees only. November 22, extension to 120 degrees. November 28, extension to 150 degrees. December 3, the same. January 3, 1907, the boy now returns complaining of tenderness (not pain) along course of median nerve. This he says has existed for some weeks. Today the nails fell off the index and middle fingers; these fingers are numb, and evidently the seat of trophic changes. Skiagraph (Fig. 84), made today, shows periosteum stripped off posterior surface of humerus for several inches, with callus formed on under surface of periosteum; this mass of callus seems to prevent full extension of elbow, as olecranon

impinges upon it. The lower end of the upper fragment is prominent anteriorly; perhaps the median nerve is stretched over it. The patient's

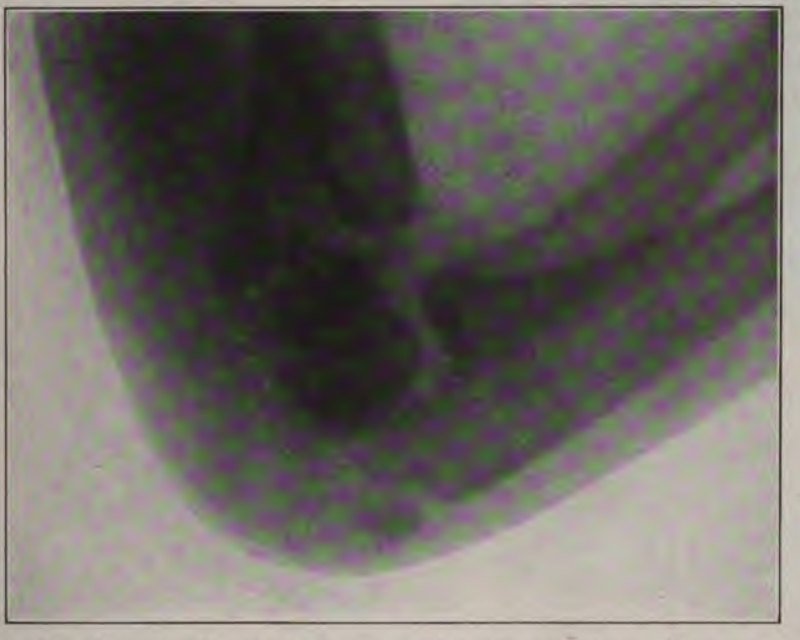

FIG. 83.—Case 11. Skiagraph of supracondylar fracture, September 22, 1906.

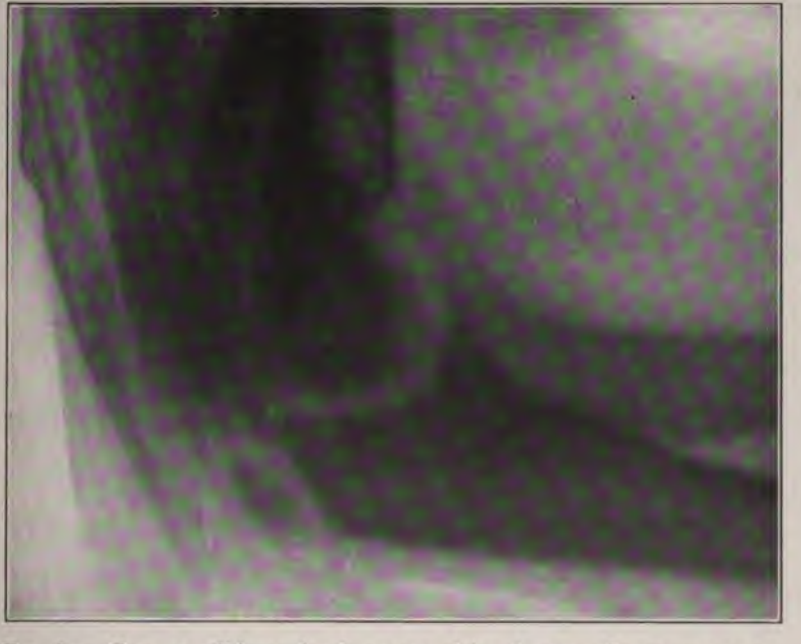

FIG. 84.—Case 11. Skiagraph of supracondylar fracture, January 3, 1907.

elbow was put on an internal angular splint, in the hope that complete rest might allow the neuritis to subside. A photograph (Fig. 85) made January 31, shows the dystrophic nails very well. As no improvement occurred under conservative measures, it was determined to resort to operation to relieve the neuritis. Accordingly, on April 2, 1907, over six months after the injury, the median nerve was exposed in front of the elbow-joint; it was found stretched over the prominent lower end of the upper fragment, shown in Fig. 84. The nerve was released from its adhesions, and the prominent bone chiselled off; layers of fascia were

FIG. 85.—Case 11. Photograph showing trophic changes in finger nails as a result of neuritis of median nerve. January 31, 1907.

FIG. 86.—Case 11. Photograph made eight weeks after operation, to show improvement in finger nails. May 28, 1907.

carefully sutured together beneath and above the nerve, and the incision was closed.[1] April 16, no tenderness along the course of median nerve remains; the nails are growing again. May 28, the accompanying photograph (Fig. 86) was made, eight weeks after operation, to show improvement in nails. The elbow can now be extended to 150 degrees, and flexed to 40 degrees. The boy has no pain, but his finger tips are still tender on deep pressure, as is also the course of the median nerve in the forearm. July 23, extension to 160 degrees. September 10, extension to 180 degrees.

[1] Operation by Dr. G. G. Davis, at the Orthopædic Hospital.

*Result.*—Examined November 5, 1907. Full flexion and full extension; carrying angle, 165 degrees (normal elbow, 170 degrees). Figs. 87 and 88 show the result.

FIG. 87.—Case 11. Photograph showing full flexion after supracondylar fracture of left humerus.

FIG. 88.—Case 11. Photograph showing full extension after supracondylar fracture of left humerus.

12. **Supracondylar Fracture of Left Humerus.**—October 25, 1906. George W. C., aged six years. Thrown in fight, landing on extensor surface of left forearm, which was in flexion. *Symptoms:* Lower fragment posterior. *Treatment:* Hyperflexion. Skiagraph (Fig. 89) made

October 29, shows good position. November 15, in sling. November 28, extension to 160 degrees.

*Result.*—Examined April 11, 1907. Full flexion, full extension; carrying angle normal. Perfect result.

13. **Supracondylar Fracture of Right Humerus.**—September 14, 1906. Marie B., aged three years. Fall. *Symptoms:* Not recorded. Dressed by resident physician at right angle. Skiagraph (Fig. 90) shows fracture still unreduced. *Treatment:* Elbow put into position of hyperflexion. September 16, 1906; at end of four weeks in sling.

*Result.*—Father reports, April 28, 1907, that elbow can be fully extended and fully flexed; carrying angle normal. Perfect result.

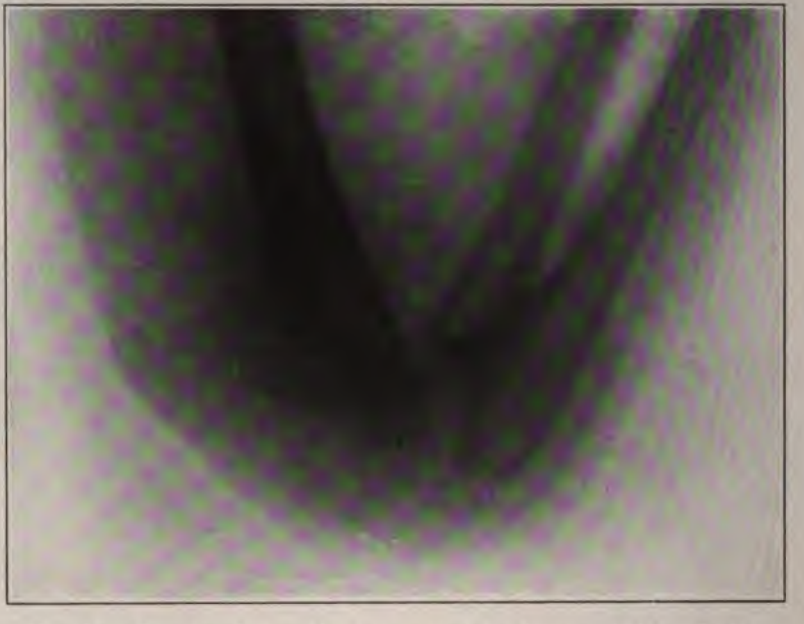

FIG. 89.—Case 12. Skiagraph of supracondylar fracture, in hyperflexion.

14. **Supracondylar Fracture of Right Humerus.**—November 17, 1906. Emma D., aged five years. From fall on overextended palm. Dressed by interne in Velpeau position. Examined by me November 19. *Symptoms:* Considerable swelling, lower fragment slides freely antero-posteriorly, producing crepitus as forearm is moved fore and aft. *Treatment:* Hyperflexion. Skiagraph (Fig. 91), made with elbow in hyperflexion, shows good position of fragments. December 12, in sling. December 17, out of sling. December 27, has fallen and bruised same elbow again; painful, and is held stiff. Ichthyol ointment applied. January 3, 1907, has been in a trolley accident, and has hurt same elbow third time. Motion is limited to a range of 30 degrees, and rotation

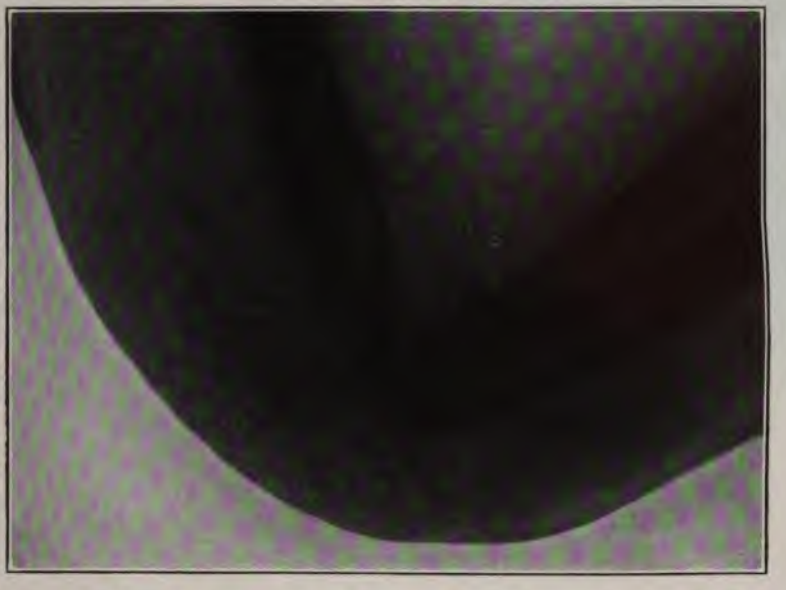

FIG. 90.—Case 16. Skiagraph of supracondylar fracture before reduction.

FIG. 91.—Case 14. Skiagraph of supracondylar fracture in hyperflexion.

of forearm is poor. Dressed on internal angular splint, with ichthyol ointment. February 14, flexion to 75 degrees, extension to 110 degrees; no pain.

*Result.*—This patient cannot be traced.

15. **Supracondylar Fracture of Right Humerus.**—December 15, 1906. Joseph M., aged four years. Fell out of express wagon yesterday evening; probably landed on elbow. *Symptoms:* Forearm in full pronation; elbow held in 165 degrees extension; active motion *nil*, but whole extremity is moved at shoulder; fingers also actively moved. Carrying angle

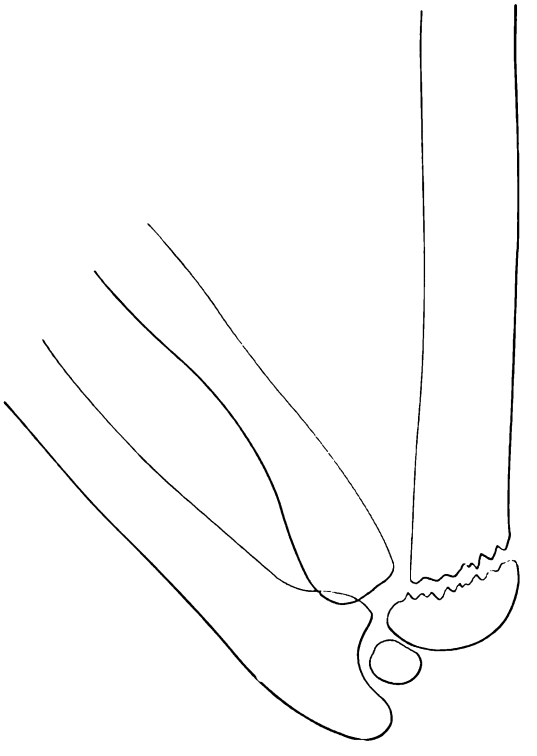

FIG. 92.—Case 15. Skiagraph of supracondylar fracture in hyperflexion.

preserved; passive rotation of forearm normal. Marked swelling over internal condyle, discoloration over external condyle. Fold of elbow looks and feels prominent. Tender over lower humerus, especially in fold of elbow. Relation of condyles to olecranon preserved. Indistinct soft crepitus on flexion and extension; no evident abnormal mobility. Diagnosis was separation of lower epiphysis, but skiagraph (Fig. 92), made December 17, shows line of fracture transverse above condyles; centre for capitellum seen below epiphyseal line. The skiagraph, however, does not exclude additional injury to cartilaginous end

of humerus. *Treatment:* Reduced by traction, hyperextension, and acute flexion; dressed in hyperflexion. Excellent position secured is shown in Fig. 92, from skiagraph made after dressing was applied. January 10, in sling.

*Result.*—Examined April 13, 1907. Full flexion and extension; carrying angle normal; all functions perfect. Perfect result.

16. **Supracondylar Fracture of Right Humerus.**—December 25, 1906. Ida D., aged twenty months. Fell off chair yesterday. *Symptoms:* Much swelling and ecchymosis. Dressed by resident physician in flexed position. Skiagraph (Fig. 90), made December 26, shows fragment still slightly posterior; centre for capitellum can be detected in clear cartilaginous area between humerus and ulna. *Treatment:* Fracture re-set, December 27, by traction, hyperextension, and acute flexion; dressed in hyperflexion.

*Result.*—Patient never returned for treatment, and cannot be traced.

FIG. 93.—Case 18. Photograph showing full flexion after recovery from supracondylar fracture.

17. **Supracondylar Fracture of Right Humerus.**—February 19, 1907. Sarah W., aged two years. *Symptoms:* Localized pain, tenderness, and swelling; slight crepitus obtained by holding shaft of humerus in one hand and rotating lower fragment on it through medium of forearm; no antero-posterior mobility. *Treatment:* Hyperflexion. Skiagraph, made today, very indistinct. February 28, extended by force to 180 degrees, to assure normal carrying angle. March 18, in sling, active extension to 160 degrees.

*Result.*—Examined March 25, 1907. Full flexion and extension; carrying angle normal. Perfect result.

18. **Supracondylar Fracture of Left Humerus.**—April 14, 1907. Katy S., aged four years. Fell on extensor surface of forearm, which was

FIG. 94.—Case 18. Skiagraph of supracondylar fracture in hyperflexion.

FIG. 95.—Case 18. Photograph showing full extension after recovery from supracondylar fracture.

flexed to right angle. Dressed by resident physician in Velpeau position. *Symptoms* (April 15): Some swelling, no displacement, no mobility, crepitus uncertain. Full flexion and extension possible, if forced. *Treatment:* Hyperflexion. Skiagraph (Fig. 94), made April 16, shows fracture transversely at base of condyles, fragment in good position; the periosteum has been stripped up off posterior surface of humerus for an inch or so.

*Result.*—Examined March 28, 1909. Full flexion, full extension; carrying angle normal. Perfect result (Figs. 93 and 95).

FIG. 96.—Case 19. Skiagraph of supracondylar fracture, antero-posterior view.

19. **Supracondylar Fracture of Left Humerus.**—July 16, 1907. John S., aged eight years. Fell last evening on overextended hand, elbow being in nearly full extension. Family physician applied ointment, bandaging the elbow in nearly full extension. Seen by me today. *Symptoms:* Elbow in almost full extension, carrying angle lost, external condyle down and posterior, olecranon and internal condyle displaced posteriorly and to inner side. Skiagraph, made today, shows, in lateral view, irregular and jagged fracture above the condyles, the epiphyseal line and capitellum being normal. Fig. 96, the antero-posterior view, is considerably obscured by the ointment and bandages, but shows an irregular fracture above the condyles, the external condyle being dis-

placed downward, causing *cubitus varus*. *Treatment:* Considerable force had to be used in reduction, causing crepitus, audible to by-standers;

FIG. 97.—Case 20. Photograph showing full flexion after recovery from supracondylar fracture.

FIG. 98.—Case 20. Photograph showing full extension after recovery from supracondylar fracture.

dressed in hyperflexion. September 5, family physician, who has treated patient since fracture was set, reports extension to 135 degrees.

*Result.*—Family physician reports, October 1, 1907, that there is complete flexion and extension, and that carrying angle is normal. Perfect result.

FIG. 99.—Case 21. Photograph showing full flexion after recovery from supracondylar fracture.

FIG. 100.—Case 21. Photograph showing full extension after recovery from supracondylar fracture.

20. **Supracondylar Fracture of Left Humerus.**—January 25, 1908. Edith S., aged six years. Fell today on extensor surface of forearm, elbow being flexed to right angle. Dressed by resident physician on anterior angular splint. Skiagraph, which unfortunately has been lost, made January 27, shows lower fragment still unreduced. *Treatment:* Dressed in hyperflexion; skiagraph made with elbow thus showed fragment still posterior. January 28, etherized and reduction attempted by forcible hyperextension, traction, and again hyperflexion. Skiagraph made after this attempt shows improvement, but still not absolutely complete reduction. It is most unfortunate that these skiagraphs have all been mislaid, owing to building changes in the hospital. February 1, dressed; swelling much less; no pain since last note. February 20, in sling. March 17, out of sling for three weeks; extension to 135 degrees. March 24, extension to 140 degrees.

*Result.*—Examined March 11, 1909. Extension to 180 degrees, flexion to 35 degrees; carrying angle normal. (Other elbow has extension to 185 degrees, flexion to 32 degrees.) Perfect result, shown in Figs. 97 and 98, from photographs made today.

21. **Supracondylar Fracture of Left Humerus.**—September 27, 1908. Martin N., aged two years. Fell out of bed, landing on extensor surface of elbow, which was flexed to a right angle. *Symptoms:* Much swelling, elbow held in nearly full extension, forearm in slight pronation; black and blue on extensor surface of upper part of ulna (slight hæmatoma?), confirming mother's account of manner in which injury was received; moderate gunstock deformity, which can be markedly increased (to about 210 degrees); cubitus valgus is also easily produced. Crepitus and point of false motion above condyles, which can be freely moved back and forth with forearm, while humerus is held still with other hand. *Treatment:* Reduced by hyperextension, traction, and hyperflexion.

*Result.*—Examined July 12, 1909. Full extension and full flexion; although the supinator region looks a little prominent in full extension, the carrying angle is found, on measurement with the goniometer, to be the same as that of normal elbow (175 degrees). Perfect result (Figs. 99 and 100).

## TRANSVERSE DIACONDYLAR FRACTURES.

22. **Transverse Diacondylar Fracture of Left Humerus.**—October 11, 1905. Josephine T., aged three years. From fall. *Symptoms* not recorded. Skiagraph (Fig. 101), made next day, shows irregular line of fracture, transversely through condyles, with slight displacement of capitellum and lower fragment posteriorly. *Treatment:* Hyperflexion for four weeks.

*Result.*—Examined December 22, 1905. Full flexion and full extension; carrying angle normal. Perfect result.

FIG. 101.—Case 22. Skiagraph of diacondylar fracture before reduction.

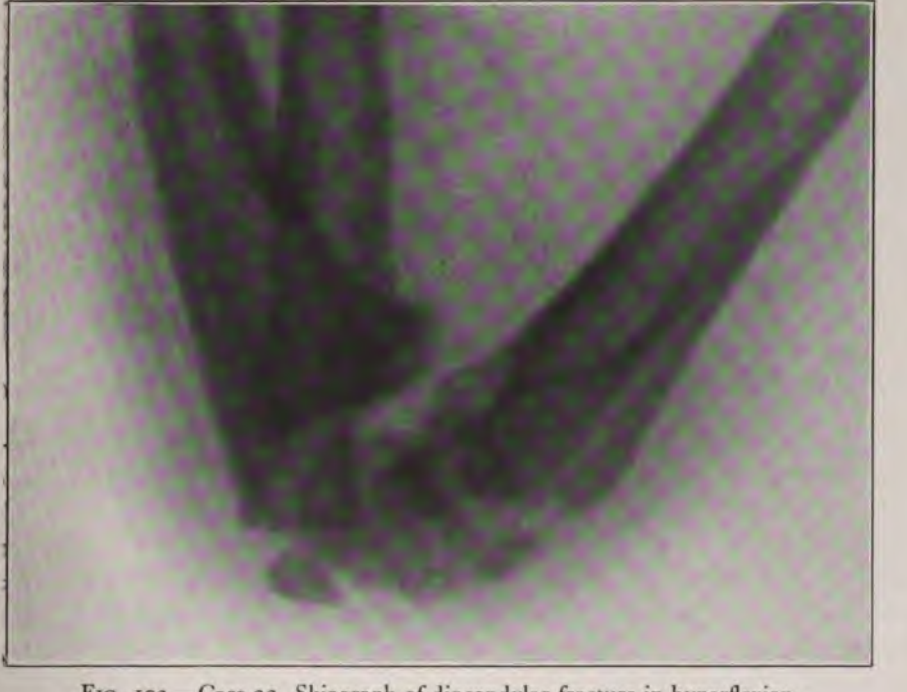

FIG. 102.—Case 23. Skiagraph of diacondylar fracture in hyperflexion.

23. **Transverse Diacondylar Fracture (Comminuted) of Right Humerus.**—November 19, 1905. Joseph B., aged thirteen years. Fell on upper part of flexed forearm. *Symptoms:* Mobility and crepitus, with outward displacement of external condyle. Skiagraph (Fig. 102), made next day, showed comminuted fracture, running more or less transversely through condyles. *Treatment:* Hyperflexion; in sling on December 19; discharged December 29, 1905, with extension to 115 degrees and no deformity.

*Result.*—June 8, 1907, brother reports extension to 165 degrees, full flexion; all functions normal; carrying angle normal; no disability.

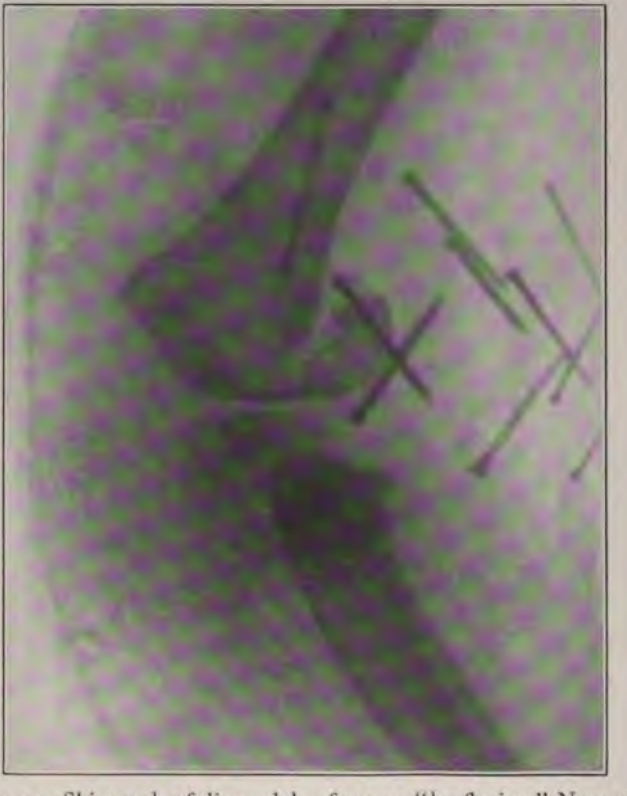

FIG. 103.—Case 24. Skiagraph of diacondylar fracture "by flexion," November 20, 1906.

24. **Transverse Diacondylar Fracture "by Flexion" of Left Humerus.**—November 18, 1906. Gertrude O'B., aged three years. Fell off a table; mother found "bony lump" projecting in region of external condyle. resident physician diagnosticated fracture of neck of radius; there was very great swelling, all up to shoulder; he dressed injury by long palmar and short dorsal splint to forearm, which was partially supinated. Seen by me next day, November 19; swelling worse; any accurate diagnosis impossible, but it was determined that injury was confined to humerus

and involved elbow-joint. *Treatment:* Anterior angular and short dorsal splint. Skiagraph (Fig. 103), made November 20, shows diacondylar fracture of humerus, with displacement of lower fragment anteriorly and inward; the arm is on an anterior angular splint, the nails of which are seen on flexor surface of elbow; owing to great swelling, it was impossible to flex elbow any more at this time. The elbow (left) is viewed obliquely from within and behind. The line of fracture passes through the condyles, more or less transversely, involving the diaphysis a short distance above the epiphyseal line, which latter is seen separating the fragment of diaphysis from the centre for capitellum. At this age this is the only centre visible. A skiagraph (Fig. 104), made November 22,

FIG. 104.—Case 24. Skiagraph of diaconylar fracture "by flexion," November 22, 1906.

gives an antero-posterior view of the left elbow, viewed from behind, in full extension; this shows the inward displacement of the lower fragment, carrying the forearm with it into a marked gunstock deformity (*cubitus varus*). The centre for the capitellum retains its normal position in relation to the head of the radius; the centre for the head of the radius is not yet visible. The bony lump felt by the mother was evidently the diaphysis just above the seat of fracture. Having now determined accurately the nature of the fracture, the child was etherized on November 23, the fifth day after the injury, and an attempt was made to reduce the fragment to its normal place; by hyperextension, direct pressure on the lower fragment, and then by hyperflexion, reduction was apparently obtained. The elbow was dressed in hyperflexion. From the

skiagraph (Fig. 105), made November 30, one week later, it is seen that some axial rotation of the lower fragment persisted; and it was thought that extension probably would be limited to about 160 degrees. December 11, in sling. December 18, extension to 135 degrees; slight *cubitus varus*.

*Result.*—Examined February 16, 1907. Flexion and extension complete; normal rotation of forearm; slight loss of carrying angle, as shown in Fig. 106, from photograph made April 15, 1907. Excellent result, considering nature of injury.

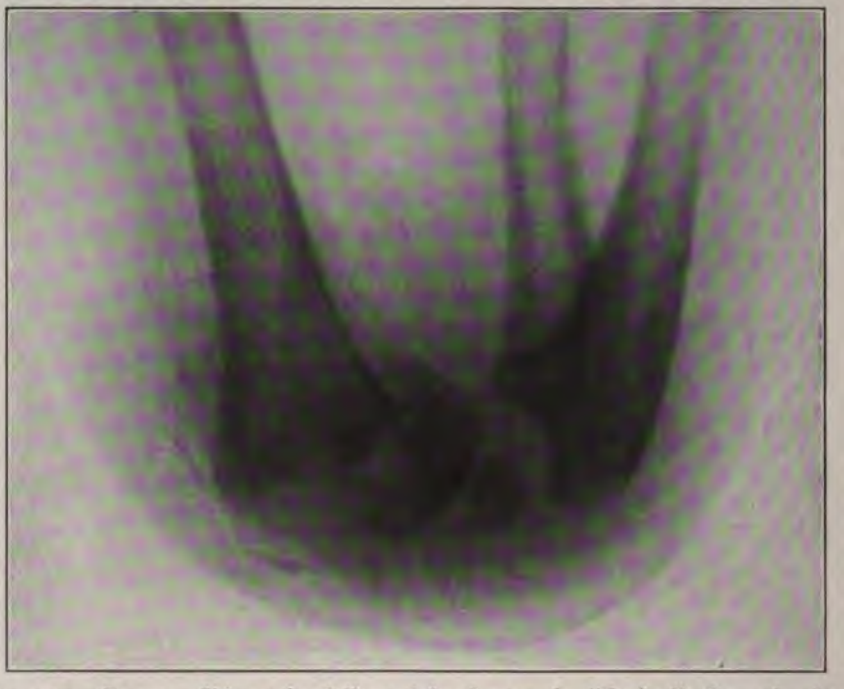

FIG. 105.—Case 24. Skiagraph of diacondylar fracture by "flexion" after reduction, November 30, 1906.

25. **Transverse Diacondylar Fracture of Left Humerus.**—March 2, 1907. Elwood H., aged five years. Fell down stairs. *Symptoms:* Crepitus and mobility. *Treatment:* Hyperflexion. Skiagraph (Fig. 107), made March 4, 1907, shows line of fracture running transversely through condyles, just above epiphyseal line. March 28, in sling.

*Result.*—Examined April 10, 1907. Full flexion and extension; carrying angle normal. Perfect result.

26. **Transverse Diacondylar Fracture of Right Humerus.**—March 29, 1907. William C., aged four years. Fell 3 feet off porch, probably striking on point of elbow. Resident physician diagnosticated "intercondyloid fracture," and dressed elbow in Velpeau position. Seen by me March

FIG. 106.—Case 24. Photograph showing end result of diacondylar fracture "by flexion;" full extension and very slight *cubitus varus*, April 15, 1907.

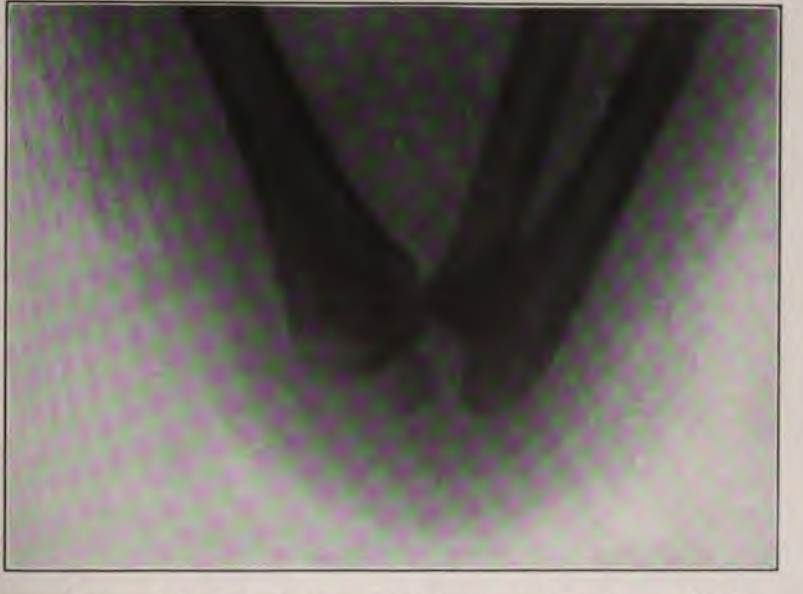

FIG. 107.—Case 25. Skiagraph of diacondylar fracture in hyperflexion, March 4, 1907.

30; restless all night; elbow much swollen, not broadened laterally, as in true intercondylar fracture; no crepitus obtained. Diagnosis, probably diacondylar fracture. *Treatment:* Hyperflexion. Skiagraph (Fig. 108), made April 2, 1907, confirms last diagnosis, showing line of fracture transversely through condyles, about three-eighths of an inch above epiphyseal line. The view is of the right elbow, seen from inner side and behind. Just below shaft of humerus is seen centre for capitellum,

FIG. 108.—Case 26. Skiagraph of diacondylar fracture in hyperflexion, April 2, 1907.

in line with shaft of radius; this is the only centre visible. March 25, in sling. March 29, out of sling, extension to 115 degrees.

*Result.*—Examined March 23, 1908. Full extension and flexion; carrying angle normal. Perfect result. It was four months after last note before full extension was obtained.

27. **Transverse Diacondylar Fracture of Right Humerus.**—July 12, 1907. Robert N., aged twelve years. On July 7 fell from railroad bumper

to ground, a distance of four feet, landing on extensor surface of flexed elbow. Treated as a recent accident elsewhere, being told his elbow was "out of joint;" was dressed on anterior splint, with Stromeyer screw at elbow. *Symptoms:* July 12, considerable swelling, ecchymosis, and blistering; same dressing reapplied. July 16, on holding humerus with one hand in middle of shaft, and rotating it with other through medium of flexed forearm, there seems to be a point of false motion near condyles of humerus, where also there is great pain and marked localized tenderness to pressure. Slight flexion and extension of elbow produces no pain. Dressed in hyperflexion. July 18, not re-dressed, no pain. July 23, no pain on extension almost to right angle; no tenderness over condyles or lower humerus, nor on rotation of humerus. Diagnosis of fracture again uncertain; but in view of nature of injury, which almost certainly could not have caused dislocation, and which was typical for diacondylar fracture, and in view of false motion and other symptoms, I concluded to diagnosticate this as fracture. Unfortunately, the hospital where the patient was treated has no X-ray plant, so the diagnosis could not be confirmed. Again dressed in acute flexion. July 30, in sling at right angle.

*Result.*—Father reports, August 15, 1909, full flexion and full extension; carrying angle normal. Perfect result.

FIG. 109.—Case 28. Photograph of diacondylar fracture of the type "Posadas" before reduction.

28. **Transverse Diacondylar Fracture (Type "Posadas") of Right Humerus.**—December 30, 1906. Louis M., aged ten years. Fell off ash cart, landing on overextended hand; elbow was thus hyperextended, producing a posterior dislocation. Two photographs were made before reducing the supposed dislocation (Figs. 109 and 110). Reduction was attempted

by the resident physician, without an anæsthetic, by flexing the elbow over the knee placed in bend of elbow. He then dressed the elbow on an internal angular splint. The patient was first seen by me the next

FIG. 110.—Case 28. Another view of same elbow before reduction.

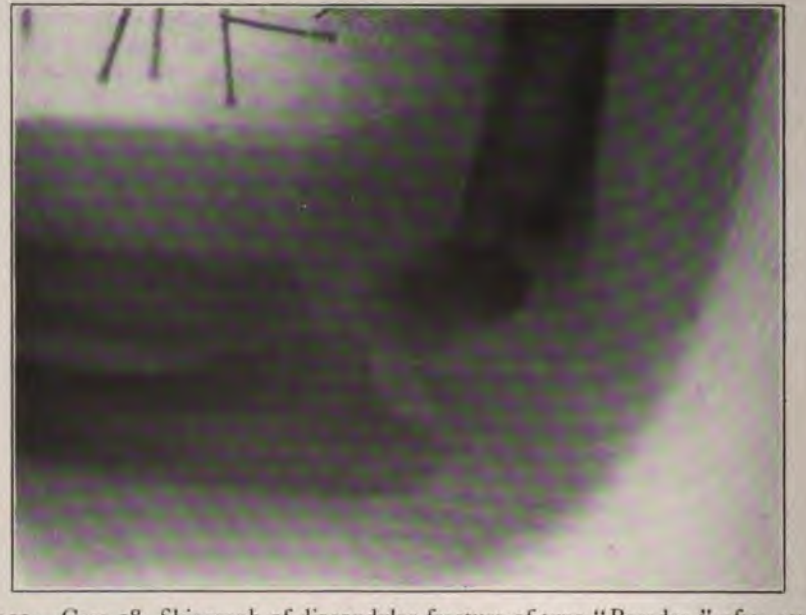

FIG. 111.—Case 28. Skiagraph of diacondylar fracture of type "Posadas," after attempt to reduce dislocation, January 3, 1907.

day, but examination was unsatisfactory on account of the swelling. The arm was placed on an anterior angular splint, as the dislocation did not seem to be entirely reduced; the possibility of fracture could not be excluded. Skiagraph (Fig. 111), made January 3, 1907, shows that there is still subluxation of bones of forearm backward, and that there is also a fracture through the condyles, with forward displacement of the lower fragment of the humerus, constituting the type described by

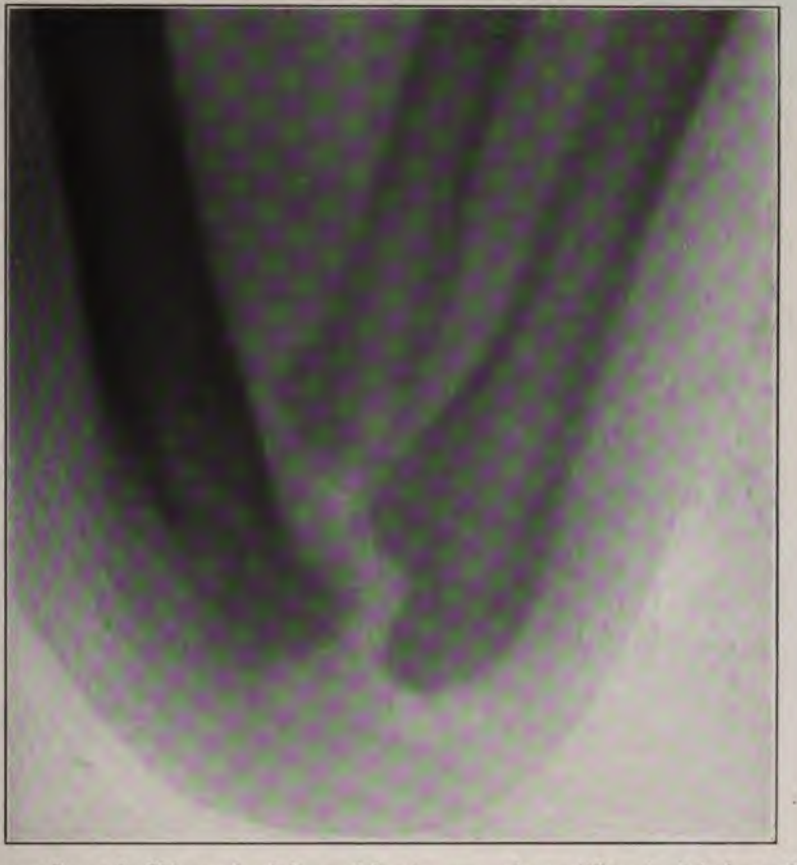

FIG. 112.—Case 28. Skiagraph of diacondylar fracture of type "Posadas" in hyperflexion, dislocation and fracture both reduced, January 18, 1907.

Prof. Posadas (p. 42). *Treatment:* Today, after seeing the skiagraph, I first made very forcible extension and counterextension, with the elbow at first fully extended and then flexed to a right angle, hoping thus to overcome the subluxation; and then, with the elbow acutely flexed, I rammed the forearm backward and downward, so as to drive the lower fragment back into place. (No anæsthetic.) The result is shown in Fig. 112, from a skiagraph made fifteen days later (January 18, 1907);

the subluxation is reduced, and the fragment has resumed its normal relation with the shaft. In Fig. 111 the small fragment lying between the olecranon and the capitellum evidently is the separated epitrochlea. Compare Cases 42 and 44, where the epitrochlea bears the same relation to the ulna, but where, owing to the more advanced age of the patients, the shadow of the centre for the trochlea can be seen also. January 7, less pain; this is mostly confined to ring and little fingers. January 10, swelling less, not tender around ulnar nerve at elbow, nor along its course in forearm. January 14, no pain since last visit. Swelling less, but callus forming around condyles. Not tender anywhere. Elbow passively extended to 80 degrees, and again dressed in hyperflexion. January 28, in sling; rotation of forearm normal. March 26, flexion to 80 degrees,

FIG. 113.—Case 28. Skiagraph of same case, lateral view, August 20, 1907.

extension to 110 degrees; a bag of shot was fitted on the boy's hand, so as gradually to increase extension.[1] April 30, active flexion to 50 degrees, and active extension to 120 degrees. August 20, flexion to 45 degrees, extension to 140 degrees (passive extension possible to 150 degrees). There is marked cubitus valgus; he still wears the shot bag at times. The fifth finger cannot be actively flexed at distal interphalangeal joint, though the other joints of this finger are normal. Two skiagraphs made today are shown in Fig. 113 and Fig. 114. The lateral view (Fig. 113) shows only a little periosteal thickening here and there; the antero-posterior view (Fig. 114) shows marked damage to external

[1] After consultation with Dr. G. G. Davis.

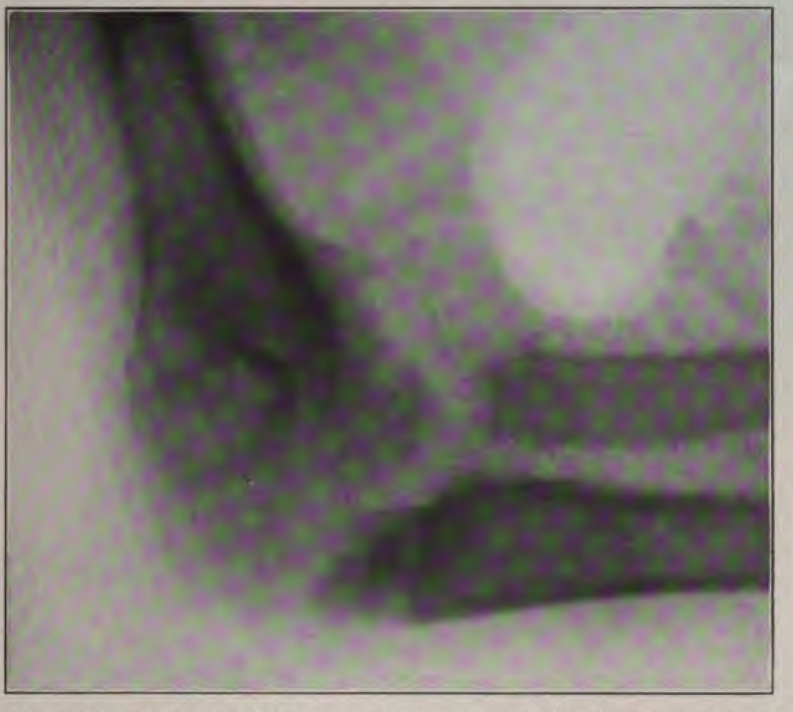

FIG. 114.—Case 28. Skiagraph of same case, antero-posterior view, August 20, 1907.

FIG. 115.—Case 28. Photograph showing full extension, with marked *cubitus valgus*, after recovery from diacondylar fracture of the type "Posadas."

condyle above capitellum, while the epiphyseal line between capitellum and diaphysis of humerus appears normal; the internal condyle has not been so much damaged, thus accounting for the *cubitus valgus*. October 1, a Stromeyer splint was applied, to increase the range of extension. Today the elbow can be extended passively to 160 degrees.

*Result.*—Examined October 15, 1907, ten months after injury. Full flexion and full extension; carrying angle, 140 degrees (Fig. 115). Internal condyle thickened, and external condyle displaced upward. Supination and pronation normal. Perfect functional use of elbow.

FIG. 116.—Case 29. Skiagraph of diacondylar fracture in hyperflexion, February 10, 1909.

29. **Transverse Diacondylar Fracture of Left Humerus.**—February 8, 1909. James G., aged fourteen years. Fell on overextended palm, elbow not fully extended. *Symptoms:* Examined within one hour; pain and marked swelling of upper third of forearm, elbow, and lower third of arm; extent of swelling remarkable, as fall had been broken by hand, and elbow had not struck ground at all. Great tenderness over joint, especially articular end of humerus. No fracture of either condyle or above

them. No distinct crepitus. *Diagnosis:* Probably epiphyseal separation. *Treatment:* Hyperflexion. Skiagraph (Fig. 116), made February 10, shows transverse diacondylar fracture, coming to surface above external condyle, and entering joint on inner side, below internal condyle. Position good. February 23, extension to 90 degrees. March 29, extension to 110 degrees.

*Result.*—Examined August 8, 1909. Full flexion and extension; carrying angle normal. Perfect result.

## FRACTURES OF THE EXTERNAL CONDYLE.

30. **Fracture of External Condyle of Left Humerus.**—October 1, 1904. Harold U., aged ten years. Fell several feet, but does not know whether he landed on hand or on elbow. *Symptoms* not recorded. *Treatment:* Hyperflexion for about three weeks; then on internal angular splint.

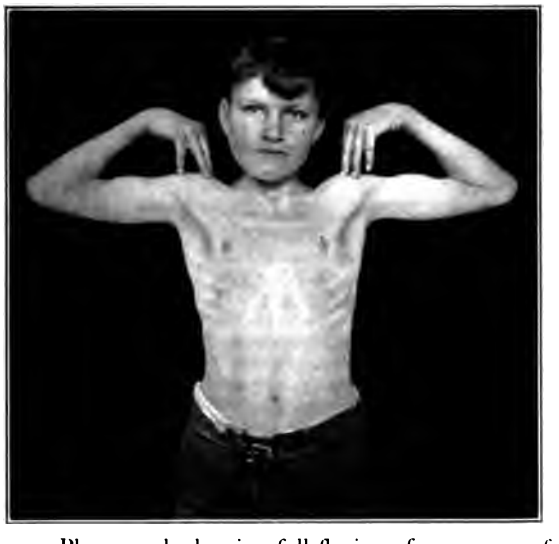

FIG. 117.—Case 30. Photograph showing full flexion after recovery from fracture of external condyle.

*Result.*—Examined April 22, 1909. Is now fifteen years old. Flexion, 30 degrees; extension, 187 degrees; carrying angle, 170 degrees; all same as in normal elbow. Figs. 117 and 118 are from photographs made today. Perfect result.

31. **Fracture of External Condyle of Left Humerus.**—December 12, 1904. Louis S., aged two and one-half years. Injury three days ago. *Symptoms:* Much cellulitis and abrasions around elbow. *Treatment:* Right-angled splint to outer surface of arm. Skiagraph has been mislaid. December 31, extension to 135 degrees, some gunstock deformity.

*Result.*—Cannot be traced.

32. **Fracture of External Condyle of Left Humerus.**—November 25, 1905. William S., aged twelve years. Fell on overextended hand. *Symptoms:*

FIG. 118.—Case 30. Photograph showing full extension after recovery from fracture of external condyle.

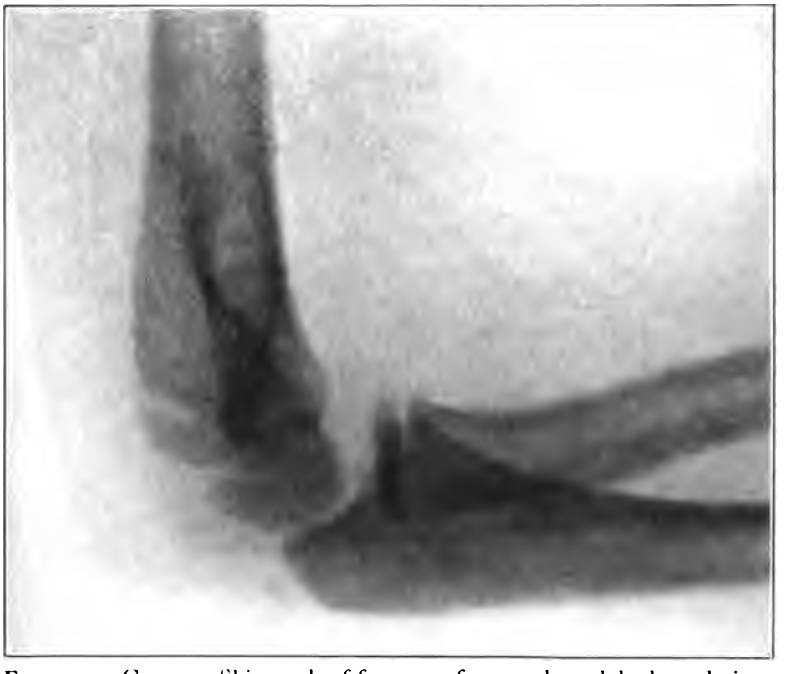

FIG. 119.—Case 32. Skiagraph of fracture of external condyle, lateral view, November 27, 1905.

No deformity, no crepitus; persistent tenderness over external condyle; no abnormal mobility. *Treatment:* Internal angular splint. Skiagraph

(Fig. 119), made November 27, shows lateral view of elbow, seen from inner side; line of fracture passes through external condyle above capitellum. Skiagraph (Fig. 120), made December 2, shows antero-posterior view of left elbow, seen from behind; above the epiphyseal line separating capitellum from diaphysis is seen a line of fracture which enters joint at point where centre for capitellum and that for trochlea (which last is barely visible) join; the outer end of line of fracture splits into two parts, only the lower extending through to the outer surface of humerus. This last fissure evidently is the fracture shown in Fig. 119. Apparently the entire fracture is subperiosteal, as the only symptom was persistent tenderness. On December 2, the elbow was put in hyperflexion, and three weeks later was carried in a sling only.

FIG. 120.—Case 32. Skiagraph of fracture of external condyle, antero-posterior view, December 2, 1905.

*Result.*—Examined January 23, 1907. Full extension, full flexion; carrying angle normal. Perfect result. Fig. 121 is from a photograph made today.

33. **Fracture of External Condyle of Left Humerus.**—July 25, 1906. William S., aged three years. Fell off porch 3 feet high, two days ago. Not treated before today. *Symptoms:* Swelling and ecchymosis; crepitus by pressing and moving external condyle on inner. *Treatment:* Hyperflexion. August 21, in sling.

*Result.*—Examined September 4, 1906. Full flexion; extension very nearly complete; very slight gunstock deformity, external condyle being prominent and axis of forearm being about 5 degrees to inner side of that of humerus. All functions normal. Excellent result, considering two days' delay in seeking treatment.

FIG. 121.—Case 32. Photograph showing full extension after recovery from fracture of external condyle.

FIG. 122.—Case 34. Skiagraph of fracture of external condyle in hyperflexion, October 30, 1906.

34. **Fracture of External Condyle of Right Humerus.**—October 27, 1906. John B., aged eleven years. Fell two weeks ago; treated at home for sprain. *Symptoms:* No deformity, but persistent pain and tenderness. *Treatment:* Hyperflexion. Skiagraph (Fig. 122), made October 30, shows fracture of external condyle, without displacement. November 17, in sling. December 10, extension to 165 degrees.

*Result.*—Examined June 8, 1907. Full flexion and extension; carrying angle normal. Perfect result.

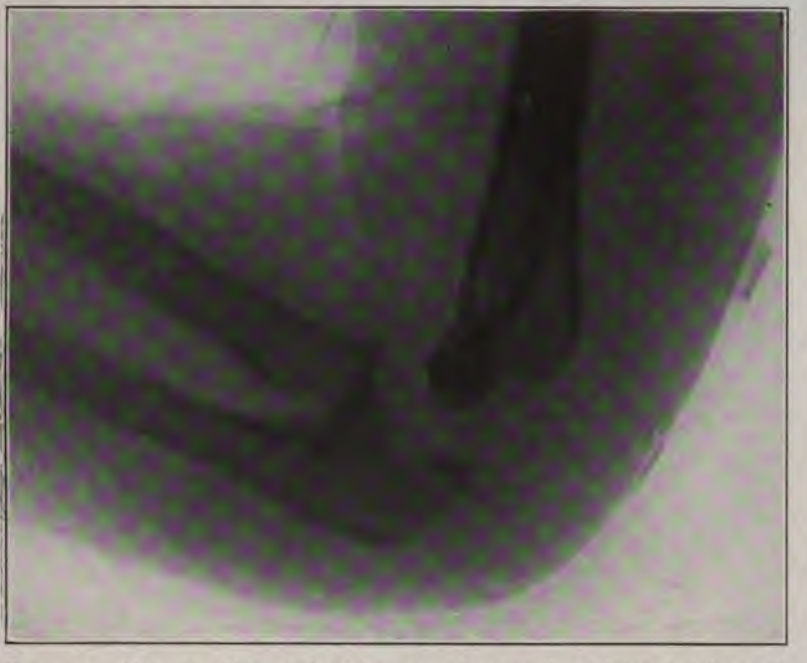

FIG. 123.—Case 35. Skiagraph of fracture of external condyle, at right angle, December 7, 1906.

35. **Fracture of External Condyle of Right Humerus.**—December 5, 1906. Harry K., aged five years. Fell down two steps on palm of overextended hand. *Symptoms:* No deformity; crepitus over external condyle, with localized pain, swelling, and tenderness. *Treatment:* Hyperflexion. Skiagraph (Fig. 123), made December 7, with elbow at right angle, does not show fracture, as elbow is seen laterally, not antero-posteriorly. There apparently is also an injury to upper end of ulna, perhaps impacted fracture, from compression of olecranon in olecranon fossa by hyperextension in original injury. The capitellum is well seen, and the centre for the head of radius is just barely visible. December 26, dressed at right angle. January 3, 1907, extension possible to 150 degrees; wearing sling.

*Result.*—Examined April 10, 1907. Full flexion, full extension; carrying angle normal. Perfect result.

36. **Fracture of External Condyle of Left Humerus.**—January 12, 1907. Florence S., aged eight years. Accident happened January 10, from fall on extensor surface of flexed forearm. Picked up by mother, who says forearm was in extreme pronation, and arm in extreme inward rotation after fall; and that as she twisted arm around again to normal position a by-stander heard the bones grit. *Symptoms:* No deformity, but crepitus, tenderness, and slight mobility of external condyle. Skiagraph (unfortunately lost), made January 13, 1907, shows fracture of external condyle. *Treatment:* Hyperflexion. February 14, extension to 135 degrees. February 21, extension to 150 degrees; supination not quite complete. February 28, extension to 170 degrees; probably will have a little *cubitus valgus*.

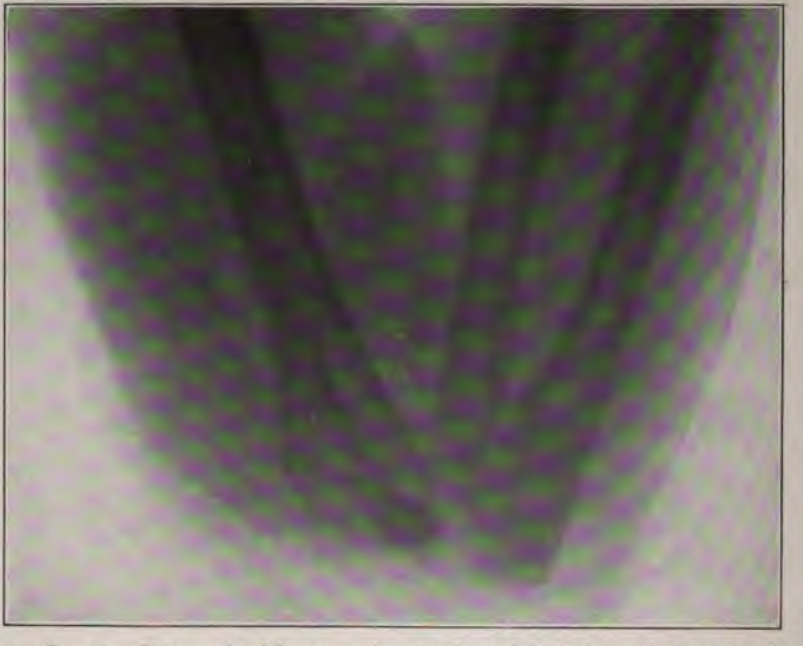

FIG. 124.—Case 37. Skiagraph of fracture of external condyle, in hyperflexion, April 2, 1907.

*Result.*—Examined February, 1908. Full flexion and full extension; carrying angle normal, no *cubitus valgus*. Supination complete. Perfect result.

37. **Fracture of External Condyle of Left Humerus.**—March 31, 1907. Mildred E., aged five years. *Symptoms:* Lower fragment (external condyle) posterior, with radius; upper fragment (shaft of humerus) forward in bend of elbow. *Treatment:* Hyperflexion. Skiagraph (Fig. 124), made April 2, shows irregular fracture of external condyle, the

elbow (left) being viewed from inner side and slightly behind. The only centre present is that for capitellum. Shadows cast by coronoid and olecranon fossæ can be clearly seen on near side of fracture. April 29, in sling.

*Result.*—Examined March 27, 1908. Full flexion and full extension; carrying angle normal. Perfect result. It was three months after last note before full extension was obtained.

38. **Fracture of External Condyle of Right Humerus.**—July 12, 1907. Daniel McD., aged three years. Fell out of go-cart yesterday; probably landed on outer side of extended elbow; certainly did not land on outstretched hand. *Symptoms:* Elbow in almost complete extension, and forearm in almost complete supination. Carrying angle lost, being about 180 degrees (Fig. 125). Tender over external condyle, which

FIG. 125.—Case 38. Photograph showing loss of carrying angle in recent fracture of external condyle of right humerus.

is displaced downward and forward; internal condyle and olecranon are normal. Marked lateral mobility in elbow-joint; forearm can be abducted beyond normal carrying angle, or adducted into marked *cubitus varus*, as external condyle glides up and down on shaft. Crepitus is slight. Internal condyle is solidly fixed to shaft, excluding both supracondylar and intercondylar fractures. *Treatment:* Hyperflexion. August 15, in sling; extension possible to 110 degrees. August 22, extension to 135 degrees; sling stopped.

*Result.*—Examined September 21, 1908. Full flexion and full extension; carrying angle normal. Perfect result.

39. **Fracture of External Condyle of Left Humerus.**—August 14, 1907. James McG., aged two and one-half years. Fell yesterday out of go-cart; it is not known how he landed. Pain in elbow all night. *Symptoms:* Holds elbow in nearly complete extension, with forearm in semipronation; moves whole extremity from shoulder. Carrying angle lost, forearm being in straight line with arm. Elbow swollen, especially over external condyle and under supinators. Black and blue over external condyle, which seems displaced a little backward and downward. Tender, but no crepitus, though condyle can be moved slightly antero-posteriorly on shaft. No evidence of supracondylar fracture. Fig. 126, from

FIG. 126.—Case 39. Photograph showing loss of carrying angle in recent fracture of external condyle of left humerus.

photograph made on admission, shows loss of carrying angle. *Treatment:* Hyperflexed, and cubitus valgus forcibly restored by abducting forearm during this manœuvre. September 3, extension to 110 degrees. September 7, extension to 120 degrees.

*Result.*—Examined September 18, 1908. Full flexion and full extension; carrying angle normal. Perfect result.

40. **Fracture of External Condyle of Left Humerus.**—September 7, 1907. Joseph S., aged 6 years. Fell yesterday off velocipede, landing on outer surface of left elbow, which was fully extended. Fracture thus was caused by excessive adduction of forearm, hand and shoulder being in contact with ground, and weight of body coming on apex of triangle formed by arm and forearm at elbow (Fig. 56). *Symptoms:* Whole

extremity is moved from shoulder; no spontaneous motion at elbow. Elbow is nearly full extension; carrying angle lost (Fig. 127). On right side carrying angle is 170 degrees. Ecchymosis over external condyle. Free lateral mobility in elbow, as detached condyle slides up and down on shaft; this is only motion which is painful, except full flexion and hyperextension. Localized tenderness over external condyle, crepitus, and abnormal mobility. *Treatment:* Hyperflexion, with restoration of carrying angle by abduction of forearm. September 10, redressed; much less swelling; no pain.

FIG. 127.—Case 40. Photograph showing loss of carrying angle in recent fracture of external condyle of left humerus.

*Result.*—Mother reports, September 22, 1908, that elbow can be fully flexed and extended, and that carrying angle is normal. Perfect result.

41. **Fracture of External Condyle of Left Humerus.**—July 21, 1909. Robt. O'N., aged three years. Fell off bed yesterday; it is not known how he landed. Dressed by resident on internal angular splint. *Symptoms:* Carrying angle lost; forearm can be adducted to 210 degrees, and abducted to 150 degrees, there being lateral motion of sixty degrees without causing much pain. Crepitus on back-and-forth movements to forearm. External condyle forward and down, moves freely with crepitus on shaft; internal condyle attached to shaft. *Treatment:* Hyperflexion, with abduction to overcome *cubitus varus*.

*Result.*—Report, October 24, 1909. Full flexion and full extension; carrying angle normal.

## FRACTURES OF THE EPITROCHLEA.

42. **Separation of Epitrochlea of Left Humerus.**—January 18, 1904. Harold N., aged twelve years. Fell January 8, 1904, striking on elbow.

FIG. 128.—Case 42. Skiagraph of separation of epitrochlea of left humerus, antero-posterior view, February 6, 1904.

FIG. 129.—Case 42. Skiagraph of separation of epitrochlea of left humerus, lateral view, February 6, 1904.

FIG. 130.—Case 42. Skiagraph of separation of epitrochlea of left humerus, antero-posterior view, April 22, 1907.

FIG. 131.—Case 43. Skiagraph of separation of epitrochlea of right humerus, two and one-half years after injury, April 28, 1907.

Treated elsewhere as recent accident. *Symptoms* (January 18): Elbow stiff and painful. *Treatment:* Hyperflexion. Skiagraph (Fig. 129), made February 6, shows lateral view of left elbow; centres for head of radius and for olecranon are seen in normal places; overlapping shadow of greater sigmoid fossa of ulna is abnormal shadow, which from antero-posterior view (Fig. 128) is seen to be centre for epitrochlea; in the

FIG. 132.—Case 44. Skiagraph of separation of epitrochlea of left humerus, September 30, 1904.

antero-posterior view it shows between shadow of ulna and that for centre for trochlea, which latter it overlaps. This is a front view of left elbow. Compare Cases 44 and 28.

*Result.*—Examined April 22, 1907. No deformity, all functions perfect. Perfect result. Skiagraph made this day (Fig. 130) shows lack of bony development of epitrochlea, and distinct shadow from displaced fragment; this is a rear view of left elbow.

43. **Separation of Epitrochlea of Right Humerus.**—September 28, 1904. Harry E., aged twelve years. Fell on overextended palm, with elbow extended. *Symptoms* not recorded. *Treatment:* Hyperflexion, for four weeks.

*Result.*—Examined April 28, 1907. Full flexion; extension to 175 degrees (practically complete); supination and pronation complete; no callus, no deformity; carrying angle normal. This amount of extension was not obtained for six months after treatment was stopped. Skiagraph (Fig. 131), made today, viewing right elbow from within and posteriorly, shows old injury to epitrochlea, not involving trochlea.

44. **Separation of Epitrochlea of Left Humerus, Complicating Posterior Dislocation of Ulna.**—September 29, 1904. Arthur T., aged fourteen years. Fall on hand; dislocation reduced by resident physician. No *symptoms* from fracture, which was discovered only by study of skiagraph (Fig. 132), where irregular fracture through olecranon is also seen (subperiosteal), and the displaced epitrochlea can be discerned, as in Case 42, overlapping shadows of olecranon and of trochlea. Compare also Case 28. *Treatment:* Hyperflexion.

*Result.*—Patient cannot be traced.

## SEPARATION OF LOWER EPIPHYSIS OF HUMERUS.

45. **Separation of Lower Epiphysis of Right Humerus.**—September 23, 1904. Elmer L., aged nine years. Fall. *Symptoms* not recorded. Skiagraph (Fig. 133), taken after dressing elbow in hyperflexion, shows no line of fracture; the line of separation passed through the epiphyseal cartilage, and the epiphysis has been replaced in normal position by hyperflexion. The elbow (right) is viewed from inner and posterior aspect; the centre for capitellum of humerus is easily seen, and that for head of radius indistinctly; the other centres have not yet appeared.

*Result.*—This patient cannot be traced.

46. **Separation of Lower Epiphysis of Left Humerus.**—August 23, 1904. Eleanor McG., aged three years. From fall. *Symptoms* not recorded. *Treatment:* Hyperflexion. Skiagraph (Fig. 134), made next day, showing left elbow viewed from behind, with forearm in pronation, shows shell of bone torn loose from diaphysis above centre for capitellum, which can be discerned overlapping shadow cast by upper end of ulna.

*Result.*—This patient cannot be traced.

47. **Separation of Lower Epiphysis of Left Humerus.**—October 14, 1905. Frank S., aged eleven years. From fall. *Symptoms:* It is noted that at end of ten days there is a loose fragment in flexure of elbow, at inner side. Skiagraph (Fig. 135) shows moderate displacement of epitrochlea,

and some irregularity of epiphyseal line between capitellum and diaphysis. Centre for trochlea has not yet appeared; that for capitellum is in normal place. *Treatment:* Hyperflexion. Skiagraph (Fig. 136), made December 12, 1905, shows epitrochlea apposed to diaphysis, though below its normal site; also an irregular mass of callus over external condyle, apparently arising from epiphyseal line between capi-

FIG. 133.—Case 45. Skiagraph of epiphyseal separation of right humerus, September 23, 1904.

tellum and diaphysis. Periosteum has also been stripped up from shaft above external condyle, and a faint shadow of newly formed bone is seen beneath it.

*Result.*—Examined February 12, 1908. Full extension and flexion and rotation; carrying angle normal. A little thickening over internal condyle. Perfect result.

48. **Separation of Lower Epiphysis of Right Humerus.**—January 10, 1907. Irene H., aged two years. Accident happened January 6; fell off table

FIG. 134.—Case 46. Skiagraph of epiphyseal separation of left humerus, August 23, 1904.

FIG. 135.—Case 47. Skiagraph of epiphyseal separation of left humerus, October 14, 1905.

FIG. 136.—Case 47. Skiagraph of epiphyseal separation of left humerus, December 12, 1905.

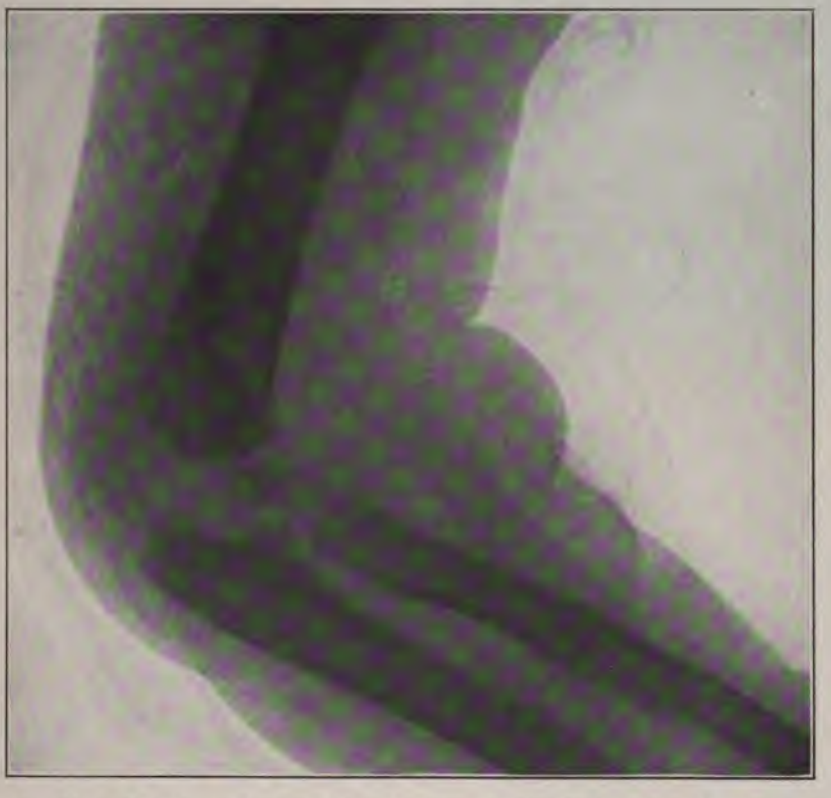

FIG. 137.—Case 48. Skiagraph of epiphyseal separation of right humerus, January 10, 1907.

FIG. 138.—Case 48. Photograph showing cubitus valgus, after recovery from epiphyseal separation of right humerus, March 28, 1908.

on to elbow, forearm being flexed at right angle. *Symptoms:* Elbow held rigid at right angle; very painful, somewhat hot, and on extension and flexion there is moist crepitus, and slight sensation of abnormal mobility; flexure of elbow seems fuller than normal. Skiagraph (Fig. 137), made January 10, excludes supracondylar fracture; as line of separation runs through cartilage (epiphyseal line), it is not visible. *Treatment:* Hyperflexion. February 7, in sling. February 14, still tender; ichthyol ointment applied. February 25, does not use it much yet; extension to 135 degrees. April 11, extension to 145 degrees, flexion to 70 degrees; uses it more. April 29, extension to 150 degrees, flexion to 70 degrees; uses it normally; slight *cubitus valgus*.

FIG. 139.—Case 49. Skiagraph of epiphyseal separation of right humerus, lateral view, March 31, 1909.

FIG. 140.—Case 49. Skiagraph of epiphyseal separation of right humerus, antero-posterior view, March 31, 1909.

*Result.*—Examined March 28, 1908. Flexion normal; extension to 170 degrees; carrying angle, 160 degrees, that of normal left elbow being 180 degrees. The slight *cubitus valgus* is shown in Fig. 138, from photograph made today.

If the diagnosis in this case had been made from the skiagraph alone, the conclusion would have been that no injury to the elbow-joint was present. The resulting deformity, however, confirms the existence of epiphyseal separation, this diagnosis being based purely on the clinical symptoms.

49. **Separation of Lower Epiphysis of Right Humerus.**—March 30, 1909. William D., aged twelve years. Fell 12 feet last night, landing on over-

extended palm. *Symptoms:* Tender over both condyles, especially over internal; no crepitus, no abnormal mobility; neither condyle movable; no fracture above condyles. *Treatment:* Hyperflexion. Skiagraph (Fig. 140), made March 31, shows irregular fracture through lower border of diaphysis above capitellum, thence passing into epiphyseal line at a point between trochlea and shaft; the centre for trochlea is

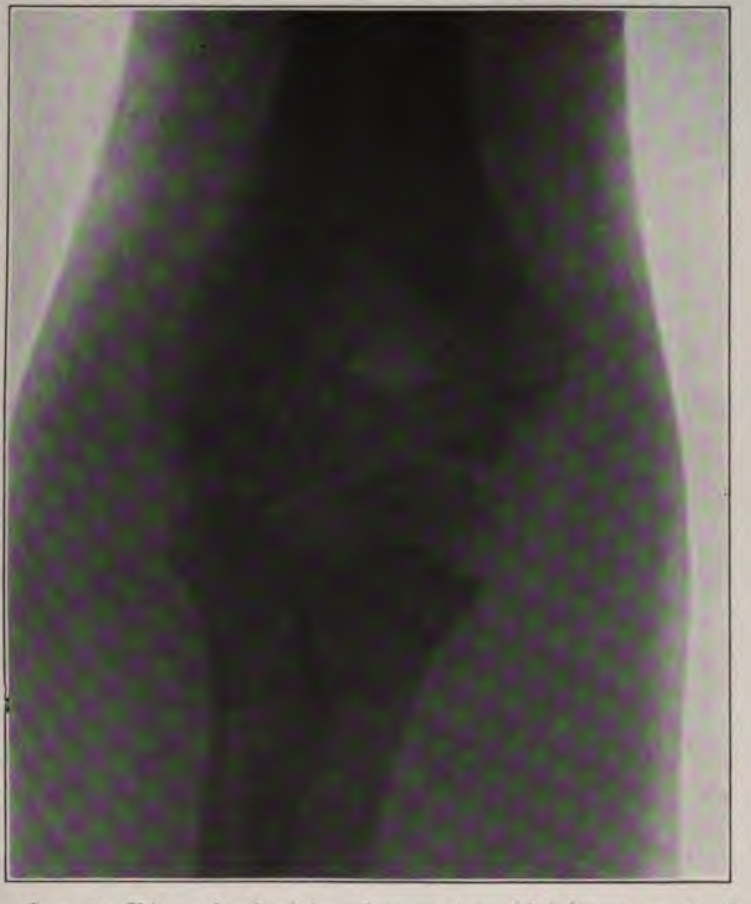

FIG. 141.—Case 50. Skiagraph of epiphyseal separation of left humerus, antero-posterior view, April 7, 1909.

displaced toward ulna, and physiological *cubitus valgus* is exaggerated; centre for epitrochlea is detached. April 5, numb over extensor surface of thumb, index, and half of ring fingers, at tips (distribution of median nerve), and also over ulnar distribution to ring and little fingers. April 16, no anæsthesia; still dressed in hyperflexion. April 19, in sling; ecchymosis has appeared over internal condyle and up inner surface of humerus. April 22, in sling still; extension to 130 degrees. April

26, flexion to 35 degrees, extension to 135 degrees. May 6, flexion, 33 degrees; extension, 175 degrees; carrying angle normal.

*Result.*—Examined August 8, 1909. Full flexion and extension; carrying angle normal. Perfect result.

50. **Separation of Lower Epiphysis of Left Humerus.**—April 6, 1909. Charles N., aged eleven years. Fell yesterday on overextended palm,

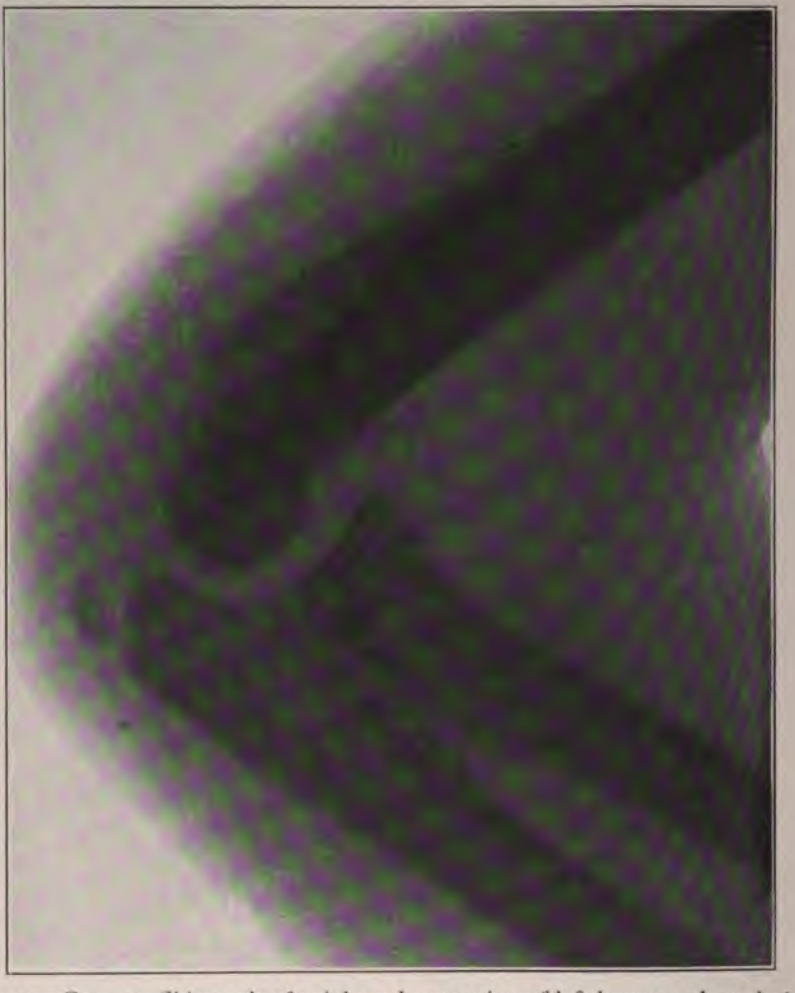

FIG. 142.—Case 50. Skiagraph of epiphyseal separation of left humerus, lateral view, April 7, 1909.

and elbow suddenly flexed; immediately experienced pain, swelling, and limitation of motion at elbow. Dressed by resident physician in hyperflexion. *Symptoms* (April 7): No crepitus, no abnormal mobility; carrying angle normal on full extension; excluded fracture above condyles or fracture of either condyle. *Diagnosis:* Contusion. Skiagraph

(Fig. 141), made April 7, shows that a shell of bone has been torn off diaphysis above centre for capitellum of humerus. *Revised diagnosis:* Epiphyseal separation. *Treatment:* Hyperflexion continued. April 19, black and blue over external condyle and head of radius. April 26, extension possible to 90 degrees; still dressed in hyperflexion.

*Result.*—August 8, 1909. Brother reports full flexion and extension; carrying angle normal. Perfect result.

FIG. 143.—Case 51. Skiagraph of epiphyseal separation of left humerus, lateral view, July 8, 1909.

51. **Separation of Lower Epiphysis of Left Humerus.** July 8, 1909. Joseph C., aged eighteen months. Yesterday mother grasped child by left elbow, which was fully extended, and picked him up off the floor. As she did so she heard a snap, but thought little of it until child cried all night, and still had pain in elbow this morning. *Symptoms:* Persistent tenderness in joint, especially in fold of elbow; no abnormal mobility, no lateral mobility; moist crepitus in flexion and extension. *Diagnosis:* Epiphyseal separation. Skiagraph (Fig. 143), made same day, shows no line of fracture; probably faint line in position of dia-condylar fracture is from defect in plate, and true line of separation is entirely cartilaginous, and so casts no shadow. *Treatment:* Hyperflexion. July 29, in sling.

*Result.*—Examined August 13, 1909. Full flexion and extension; carrying angle normal.

FIG. 144.—Case 51. Skiagraph of epiphyseal separation of left humerus, antero-posterior view, July 8, 1909.

## FRACTURES OF THE INTERNAL CONDYLE.

52. **Fracture of Internal Condyle of Humerus.**—September 12, 1903. Joseph R., aged 42 years. Injury two weeks ago. *Symptoms* not recorded. No notes.

*Result.*—This patient cannot be traced.

53. **Fracture of Internal Condyle of Left Humerus.**—April 28, 1904. George S., aged seventeen years. Fell on internal condyle of left humerus, with elbow in acute flexion. Dressed by resident on internal angular splint. Seen by me next day. *Symptoms:* Great swelling of elbow, mobility and crepitus of internal condyle. Skiagraph (Fig. 145) shows fracture of epitrochlea and outer surface of trochlea, in one piece, with complete rotation of the fragment on its longitudinal axis. *Treatment:* Hyperflexion for five weeks; then in a sling for short time. There was no injury of ulnar nerve.

*Result.*—Examined April 27, 1907, three years after the fracture. Full flexion; extension only to 150 degrees; supination and pronation

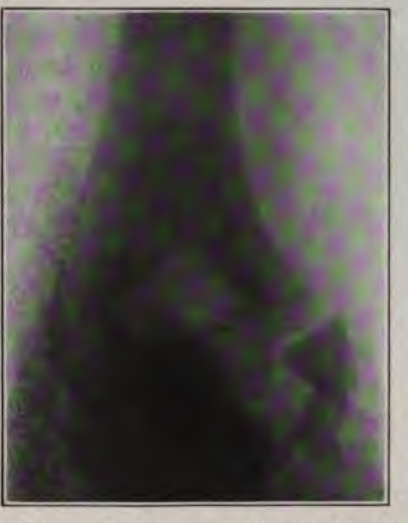

FIG. 145.—Case 53. Skiagraph of fracture of internal condyle of left humerus, April 28, 1904.

FIG. 146.—Case 53. Photograph showing *cubitus valgus* after recovery from fracture of internal condyle, April 27, 1907.

FIG. 147.—Case 53. Skiagraph of old fracture of internal condyle, April 27, 1907.

complete; slight *cubitus valgus*, about 160 degrees (Fig. 146). The epitrochlea is displaced downward 3.5 cm., compared with other arm.

There is no disability. Skiagraph today (Fig. 147) shows fragment still displaced; also indicates the degree of extension.

This case would at present be considered one suitable for operation to correct rotation of fragment in recent fracture. In the endeavor to avoid gunstock deformity (especially to be feared in fractures of internal condyle) I produced *cubitus valgus*, which, however, is much

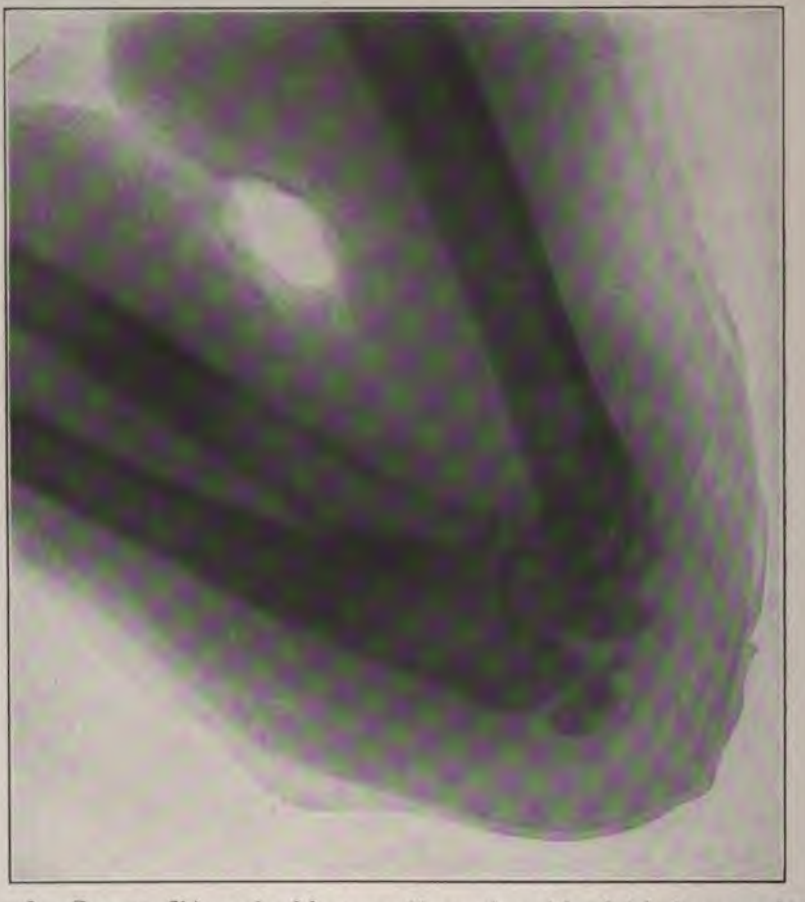

FIG. 148.—Case 55. Skiagraph of fracture of internal condyle of right humerus, lateral view, January 8, 1909.

less disabling, and caused this patient no inconvenience whatever in his work. Even with operation it is doubtful if a better functional result could have been obtained.

54. **Fracture of Internal Condyle of Left Humerus.**—December 8, 1904. Harry D., aged two years. *Symptoms* not recorded. *Treatment:* Hyperflexion.

*Result.*—Examined January 3, 1905. Full flexion and extension; carrying angle normal.

55. **Fracture of Internal Condyle of Right Humerus.**—January 7, 1909. Stanley S., aged fourteen years. Fell on point of flexed elbow. *Symptoms:* Swelling; mobility of internal condyle on shaft; no fracture above condyles; no injury to external condyle detected. *Treatment:* Hyperflexion. Skiagraph (Fig. 148), made January 8, shows good position;

FIG. 149.—Case 55. Fracture of internal condyle of right humerus, three months after injury (antero-posterior).

also slight separation of epiphysis of olecranon. January 25, dressed at right angle. February 12, extension to 115 degrees. March 28, flexion to 45 degrees, extension to 140 degrees. April 5, skiagraph (Fig. 149) shows considerable thickening in joint; apparently injury was separation of epiphysis of trochlea, epitrochlea, and olecranon. Periosteum is stripped from diaphysis above epitrochlea. April 26, flexion to 40 degrees, extension to 150 degrees.

*Result.*—August 13, 1909. Full flexion and extension; carrying angle normal.

## INTERCONDYLAR FRACTURE.

56. **Intercondylar Fracture of Right Humerus.**—January 17, 1904. Mike C., aged twenty-eight years. Intoxicated; does not know how he was injured. *Symptoms:* Internal condyle down and forward; crepitus and mobility of internal condyle on shaft. No injury to external condyle detected clinically. *Treatment:* Hyperflexion. Skiagraph (Fig. 150), made

FIG. 150.—Case 56. Skiagraph of intercondylar fracture of right humerus, antero-posterior view, February 9, 1904.

February 9, 1904, twenty-three days after injury, shows full extension of forearm on arm, with internal condyle split off, joint being entered through trochlear surface; also a fracture of external condyle, apparently impacted. Slight gunstock deformity seen in skiagraph.

*Result.*—Full extension, with slight gunstock deformity at end of three weeks; impossible to trace patient further.

# INDEX OF NAMES

# GENERAL INDEX

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G



H



I



J



L



M



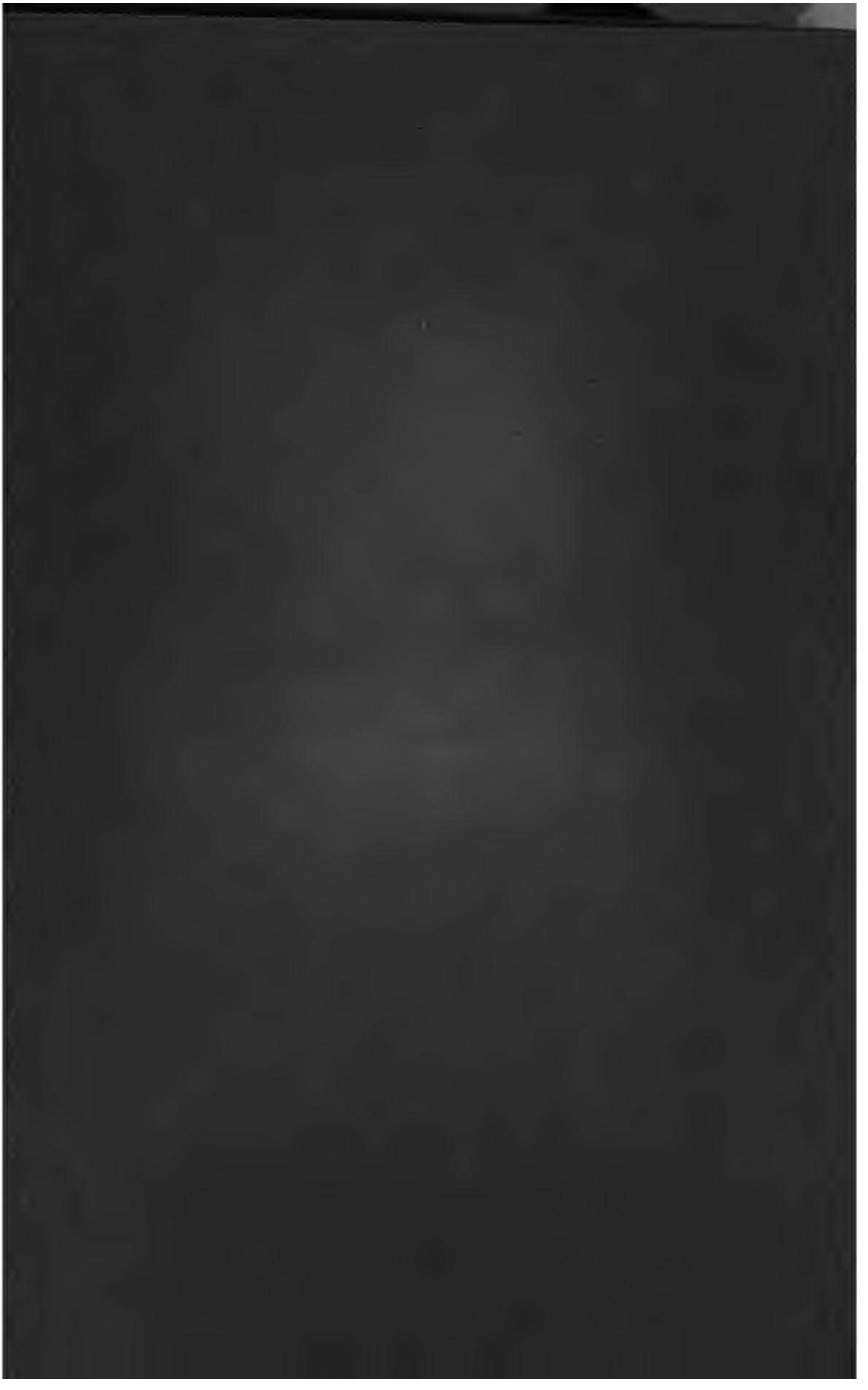
N



O



P

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Ashhurst, A.P.C.
Anatomical and surgical
study of the fractures
of the lower end of the
humerus.
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B.L. Dahlen Mat Sci
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